THE TELEGRAPHIC JOURNAL AND

Electrical Review.

VOL. XXI.—No. 514.

THE HEXTHORPE ACCIDENT.

AS was to be anticipated, the enquiry, so far, has culminated in the commitment for trial of the engine driver and his fireman. Both these men admit having received the notices issued with respect to the special arrangements for working the traffic on the occasion in question; the latter admits, further, that he had not read them. Both were fully acquainted with the system of working the race traffic—a system pursued for several years past. Both men were sober at the time. It is, therefore, difficult to account for the unfortunate occurrence otherwise than by assuming that by some means they forgot all about the race meeting and the instructions together, and we fear we must add to this, some want of care in looking out for signals, and, possibly, somewhat too great reliance upon the automatic break.

It is not, however, our desire to dwell upon the omissions, or otherwise, of the men, so much as to point out the lesson to be derived from the sad result. Hexthorpe Junction is distant from the Cherry Tree (Doncaster station) box a distance of some mile and a quarter—scarcely so much. It was this section on which the block was suspended, and it was in this section that the temporary ticket platform was erected —not newly, for it had been in use for many years. This ticket platform was out of the view of the junction box, and being within a curve it was only seen from the main line when within some 200 yards of it. Moreover, there was a falling gradient from the junction to the ticket platform. These are the salient points.

The time which it would occupy a train to traverse this section in ordinary course would be, say, three minutes. The time in which a train would traverse the preceding section would possibly not exceed two minutes. If we add three minutes for the collection of tickets, we get six minutes for the ticket collecting section, as against two for the preceding section. Thus, then, had the block been retained in the ticket platform section, as ordinarily arranged, it is clear all trains would have experienced a delay, which with a heavy traffic, such as has to be dealt with on a Leger or Cup day, would have been intolerable. It was with the object of facilitating traffic, then, we may conclude, that the block was suspended. That the traffic had been worked upon this system for years without mishap till the present occasion arose, goes to show that, however good in its way, it is not good enough to be relied upon for the future, and we doubt not that ere another Doncaster meeting is held we shall see a marked improvement in the arrangements for working the traffic over this part of the line. The end sought by the executive in suspending the block would, we cannot help thinking, have been attained equally well, and with greater security, by the insertion of one or two additional block posts. No doubt this would have made short sections, but it would have insured careful working. To meet such special traffic it is not necessary that the block posts should be constantly in use. Let them be permanently established for the race-traffic, and worked only on the race-days. Such a course would, we feel, insure a more careful regard of the signals than can possibly be obtained from flag signalling, not that the value of such signalling should in any way be depreciated, for it is impossible to entirely dispense with it. We question, however, if it would not, in all cases where it is employed, be better to lay down fog signals whenever the danger signal has to be displayed. With race traffic we fully recognise the difficulty in this; still it is clear drivers do not in all cases look out well for such signalling. Doubtless the Board of Trade enquiry will result in recommendations which will bring about such arrangements as are here suggested, and possibly such as will place the ticket platform more under the view and protection of one or more block posts, and apart from any curve of the line. The propriety of a siding for the collection of tickets is also a point for consideration.

We cannot bring our remarks to a close without expressing our high appreciation of the honourable manner in which the M.S. and L. Company has met the calamity which has fallen upon it. There has been no shirking of duty or responsibility. The former has been performed and the latter acknowledged in a manner in every way creditable to the company, and to the entire railway service of the country.

ELECTRIC LIGHTING IN DUBLIN.

WE learn from the Dublin *Daily Express* that there is at length some reasonable prospect of at least a partial introduction of electric lighting into the leading thoroughfares of Dublin. The subject has been under the consideration of the Town Council since the 20th of May last, when a resolution was passed that a committee of the whole house should inquire into the sufficiency of the water power in the control of the Corporation at Island Bridge to supply the electric light. By a subsequent order, dated 18th July, the committee were directed to inquire also into the rights of the Corporation in relation to the fishery at Island Bridge. The committee set about their task in a business-like manner by employing professional experts to examine and report.

Mr. Spencer Harty, the city engineer, was requested to ascertain the area, velocity, and horse-power of the mill races at Island Bridge, and the most suitable description of turbine, and he reported that from observations which were made on the 6th, 7th, and 8th of June, he found that the effective horse-power to high water was 27 H.P., and to low water 52 H.P. These observations are said to be thoroughly accurate, and were made with the conditions of sluices, &c., as found.

On the 10th and 11th May similar observations were made, but under different circumstances. It was then found that the horse-power to high water was about 50 H.P., and to low water about 98. The power will be a variable one, and will always be affected by dry weather, winter floods, and high and low water in the river. The committee subsequently retained the services of Mr. E. Manville, of the United Electrical Engineering Company, which our readers may remember was formerly known as the Jablochkoff. He visited Dublin, and, in the absence of the city engineer, consulted with his assistants, Mr. Andrews, C.E., and Mr. Allen, C.E., and inspected the premises at Island Bridge, accompanied by a sub-committee.

Mr. Manville sent in a report in which he estimated that from the observations made during a time of drought by the hydraulic engineer it would appear that there is never less than 50 horse-power available for the purpose, and, whilst in the winter it was far in excess of this, the power at disposal was sufficient to produce current for 45 lamps, giving an actual light of 1,000 candle-power each.

Mr. Manville further estimated that the following plant would be required :—Buildings ; two turbines, and erection of same ; shafting, pulleys ; two dynamos ; sliding beds, and erection of same ; switchboard ; nine and a half miles of lead covered main for two double circuits to O'Connell Bridge, and erection of cable ; poles and insulators for Conyngham Road, and erection ; three miles of street mains, and erection ; fifty arc lamps and fittings, 50 lamp posts, and erection ; sundry materials and carriage—£4,134.

If the mains were laid underground, the extra cost of providing bitumen cases, and laying same when the streets have been opened, is calculated as being about £460 ; and if it is thought desirable to put in an engine and boiler in addition to the turbines, the extra cost for this is set down at £602 ; so that the outside cost of the installation, if the mains are laid underground, and if an engine and boiler are provided in addition to the turbines, will not exceed the sum of £5,200.

The annual maintenance is thus set forth :—Assuming that the whole 45 lamps burn until 11.30 p.m. every night—we suppose that the lighting is intended to commence at dusk, although there is no reference in the report to this—and that after that hour only 20 are left burning until daylight, the total number of lamp hours burnt in the year will be 120,000.

Interest and depreciation—10 per cent on £4,134	£413	0	0
Wages—2 men at 30s. per week ...	156	0	0
„ 1 man at 40s. „ ...	104	0	0
„ 1 „ 20s. „ ...	52	0	0
Carbons for 120,000 lamp hours ...	300	0	0
Sundries, oil, and waste	100	0	0
Supervision	50	0	0
	£1,175	0	0

If the mains are laid underground, and the engine and boiler are also provided, the maintenance will be increased by £50, being interest and depreciation on an extra £1,000.

The total number of gas-burners proposed to be replaced by arc lamps is 308, and the city accountant makes the annual cost of maintenance on each gas-burner £2 17s. 6½d., so that the 308 burners cost £886 3s. per annum, as against £1,175 for electric lighting, or a balance of £287 in favour of gas ; but whereas the total actual candle-power of the gas-burners, on the most liberal estimate, will not exceed 3,080 candles, which shows that the Dublin gas is of very inferior illuminating quality, the total actual candle-power of the electric lamps will be 45,000, or 15 times as much as the gas.

Mr. Manville further advises the committee that if it is not considered advisable to spend more on electric lighting than has been spent on gas, the lamps could be spread over a larger area, so as to replace another 100 gas-burners, which would then make the price of electric and gas lighting equal, still leaving a large balance in favour of the electric light from the illuminating point of view.

Having obtained the scientific information which they required, the committee next instructed the law agent to report as to whether they were legally entitled to use the electric light, and what steps should be taken to empower them. His report was to the effect that it would be necessary to obtain a license from the Board of Trade.

The committee having given the subject careful attention has recommended that the water-power at Island Bridge be utilised to light the thoroughfares as proposed by Mr. Manville.

The examination of the committee into this very important object seems to have been carried out very thoroughly, and we hope to see the fruits of their earnestness brought to a successful issue.

THE members of the Library Association of Great Britian have been in conclave at Birmingham, and, amongst other questions connected with the practice of their profession they, as might have been expected, discussed such practical problems as the best bindings for books and the best way of preserving the books after they are bound. The effect of gas upon the bindings of books is an evil with which every librarian and every owner of a library is familiar. Complaint was once more made of this evil at Birmingham, but no one seems to have suggested, what to many people must be obvious, namely, that in the electric light a perfect escape from this trouble is to be found. The *Times* last Friday made this remark when commenting upon the subject : "The electric light solves all difficulties and completely cures the evil, and it ought not to be difficult for every library of importance to apply this remedy."

ELECTRIC locomotion seems likely to get hold of the public ear at last—and it is quite time it did. A financial contemporary predicts another electric boom, and announces that an Electric Car Company is shortly to be launched. We thought an electric car company had already been launched, but if the formation of another with that specific name attracts public attention to the advantages and capabilities of electric modes of traction for street traffic, we shall not be reluctant to welcome it.

THE HISTORY OF THE PHONIC WHEEL AND ITS APPLICATION TO SYNCHRONOUS MULTIPLEX TELEGRAPHY.

By PAUL LA COUR.

(*Translated from the Danish.*)

A LONG time, generally speaking, elapses before an invention is brought into common use, but there are exceptions, as, for example, the telephone, which in the course of a few years attained a widespread application, and it is often difficult to trace the first origin and historical development of an invention, which is too commonly looked upon as originating from the individual especially engaged in its introduction into practical use.

In the ELECTRICAL REVIEW of the 26th of August, 1887, there appeared an important and able article on the synchronism which Patrick B. Delany uses for multiplex telegraphy, and which he calls his invention. This synchronism will probably in future form the basis of different kinds of telegraphy (it is the same as that which Cassagnes, in France, applies to his well-known and ingenious steno-telegraphy), and a historical account of the origin of the same will probably, therefore, be of interest to the readers of this paper.

In the years 1874 and 1875 I was experimenting with a telegraphic system, in which I, by means of tuning forks of different pitch, produced different intermittent electrical currents that could be worked by several telegraph operators on the same wire. During these experiments I was struck by the exact manner in which a current can be made intermittent by means of a tuning fork, and the idea occurred to me whether I could not construct a motor, the movements of which would be controlled by these forks in the same manner as a clock is controlled by the pendulum. I saw at once that owing to the great velocity of the tuning fork there could in this case be no question of a mechanical action, as in the escapement of a clock; but I was fortunate enough to hit upon a new mode of motion, and to contrive an instrument which solved this problem. This instrument is the *phonic wheel* (fig. 1).

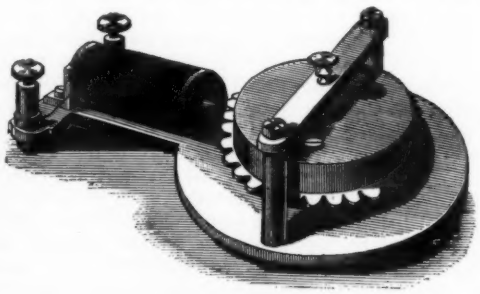


FIG. 1.

It is very simple, and consists of nothing but an electro-magnet and a cog-wheel of soft iron. The intermittent current formed by the tuning fork passes through the electro-magnet, and this latter becomes magnetised and demagnetised in exact time with the oscillation of the tuning fork. The cog-wheel turns on a vertical axis, so that its teeth pass close by the pole or poles of the electro-magnet without touching, and in such a manner that the wheel is in no mechanical or electrical connection with the electro-magnet. The wheel is thus perfectly free, and is only acted upon by the intermittent magnetic attractions.

The following is the theory upon which I based this instrument :—

In fig. 2 r is the centre of the wheel, m the pole of the electro-magnet, s a tooth at the moment when m commences to be magnetic, t the same tooth at the instant when m ceases to be magnetic. If the wheel has such a movement that a tooth passes every time m becomes magnetised, and, further, that part of the magnetic attraction which accelerates the movement of the wheel (during the movement of the tooth from s to m), is equal to that part of the magnetic attraction which checks its movement (during the movement of the tooth from m to t), then the wheel will be as much accelerated as retarded, and its velocity will remain unaltered—it will be *uniform*. In short, it will be in a state of *dynamic equilibrium*, which may be, as in the case of *static* equilibrium, either stable, unstable, or indifferent. This question is decided as at static equilibrium by imagining the movement altered by a small outer force, and after that

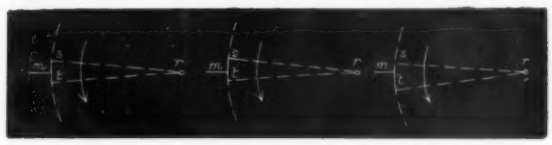


FIG. 2. FIG. 3. FIG. 4.

investigating whether the wheel left to itself will return to its former state of motion, whether it will remain in the new, or if it will depart still further from its former state of motion. Let us first imagine that an outer force had a slightly retarding influence on the wheel. A later tooth then moves, as fig. 3 shows, from s to t, while m is magnetic. It then becomes more accelerated than retarded, for s, m, is larger than m, t, and as the wheel becomes more accelerated it regains its former motion. Again, let us imagine that an outer force acts with a little acceleration upon the wheel. A later tooth then moves, as fig. 4 shows, from s to t, while m is magnetic, and it consequently is less accelerated than retarded, s, m, being smaller than m, t, and as the wheel hereby becomes less accelerated than retarded it resumes it former motion. It is thus seen that the wheel in both cases returns to its former motion, which must therefore be stable, and my experiments in 1876 entirely confirm this theory. This was quite a new kind of equilibrium of great physical interest, and it has provided us with the means of producing a motion the evenness of which far surpasses those formerly known, even that of the pendulum clock, when due regard is taken to the small intervals of time in which the clock moves from second to second. As the movement of a clock is independent of the variations of the motive power, friction, &c., and is only determined by the pendulum's time of oscillation, so the movement of the phonic wheel is independent of the strength of the electric current or of the work which it has to perform, and is regulated only by the tuning fork's time of oscillation. My investigations of this new movement and the instrument used, namely, the phonic wheel, as well as an account of its scientific and practical applications, were published in a pamphlet, written by me in Danish and French in 1878*, and I refer the reader to this for further study of the phonic wheel. Be it here sufficient to say that I arranged concentric with the axis of the phonic wheel a cylindrical reservoir with mercury, by which arrangement I secured a more uniform movement, and prevented the wheel from losing its equilibrium during the rotation.

The invention of the phonic wheel, which history will probably acknowledge as the principal part of the question treated of here, no one as yet has attempted to deprive me of. Some have, however, tried to appropriate the synchronism which I afterwards established by means of the phonic wheel, and they wished to represent this as another form of a motor, and even called the instrument a motor pure and simple, as if there was nothing new in it. A closer investigation will, however, prove that the kind of motion obtained by the phonic wheel is an absolute novelty in the field of physical science, which enables us to deal with many difficult problems.

One of the problems which the phonic wheel is called upon to solve, is the important one of making

* La Roue Phonique par M. La Cour, Copenhague, 1878. An extract of this pamphlet was published in the No. of the REVIEW for December 1st, 1878.

two instruments at two different stations move with absolute synchronism, and it is clearly easier to attain this when one is in possession of an instrument of an extraordinarily even movement. To this end an arm, which also rotates with the wheel, is fixed upon each axis of two phonic wheels with 30 teeth. During the process of rotation this arm successively touches 60 metallic segments, which are arranged in a circle as in Hughes's, Granfeld's, Meyer's, Baudot's, and other multiplex telegraphs. These two arms are in electric connection with the wire, and when they are synchronised the corresponding metallic segments will come successively in connection with one another, and thus make multiple telegraphy possible, as in the case of the other systems named above. To synchronise the wheels, my *first* plan was as follows :—At Station I. every other metallic segment was put in connection with one, say the negative pole of a battery, the other pole of which was put to earth. The tuning fork at Station I. determines the speed of the phonic wheel there, and from this a negative current is sent every time the arm touches the metallic segments named above. Station II. is consequently receiving an intermittent current, which passes through the electro-magnets of the tuning fork No. 2 ; this latter is tuned to the same pitch as No. 1, but is not driven by any local battery. By this means tuning fork No. 2 is kept in oscillations, which are synchronous with No. 1, for I have formerly proved that when a fork is kept oscillating in this manner it will swing perfectly synchronously with the intermittent current even if its natural pitch deviates somewhat. In case it differs much, it will not swing at all. The tuning fork, No. 2, causes then again a local electric current to be intermittent, and this keeps No. 2 wheel in synchronous motion with No. 1. This method of synchronising monopolised, however, the wire too much for the maintenance of the synchronism alone, for every other metallic segment (in this case 30 out of the 60) were employed for this purpose. It soon became evident, however, that very little was required to maintain the oscillation of the tuning fork, and that many of the 30 metallic segments could be dispensed with, the result being finally that six or even three only were reserved for the maintenance of the synchronism, while 54 or 57 could be utilised for telegraphic purposes.

As previous to this many telegraph systems existed, which were based upon synchronous movements and still more projects, which have failed on account of the synchronism being too unreliable and expensive, I did not attempt to construct new telegraphic systems or instruments, partly because I could not afford the heavy expenses which such new constructions would entail ; my principal object was therefore to have my synchronism tested on a telegraph wire, and under the management of ordinary telegraph operators, and to this end I obtained permission from the Director of the Danish Government Telegraphs in the year 1880 to join up two phonic wheels, synchronised as above, at the telegraph offices at Fredericia and Nyborg. As a proof of synchronism the metallic segments 1, 4, 7 . . . at each station were connected, also the segments 2, 5, 8 . . . . and finally the segments 3, 6, 9. . . . . The first were at each station put in connection with an ordinary Morse key with battery and a Morse instrument, and it would consequently be a proof of synchronism when each of the three sets of clerks could continually and at any moment signal with one another. The traffic between these two towns was, however, so small, that not even once during the three weeks the experiment lasted, did an opportunity arise of sending three messages at one time, except when the operators did so to test the synchronism, and it was thus immaterial that the instruments which were used for this test could only work slowly. To ascertain whether the synchronism was easy to manage I left the stations, and was absent during the whole series of experiments, which were carried on by the staff of operators unaided. The instruments were generally set going every morning, and the state of the synchronism was tested frequently during the day by the sending of messages, &c. Nothing was done to the synchronism until the evening, when the connections were broken off. The telegraphists kept a journal of the experiments, and they have since, according to my wish, and after some American gentlemen, of whom I shall speak later on, commenced to doubt my synchronism, given the following declaration :—

According to the wish of Mr. P. La Cour (Graduate in Physical Science of the University of Copenhagen), a wire between Fredericia and Nyborg has been employed for 24 days, *i.e.*, from June 17th to July 10th, 1880, in experimenting with a system of multiplex telegraphy at which a phonic wheel at each of the stations acted as distributor. The following is the result of the experiments :—

1. That the synchronism was easy to maintain. After some difficulties, which appeared during the first few days, there was no interruption in the synchronous movement of the phonic wheels from the morning when they were started to the evening when they were stopped, during the period of 19 days in which the system was tried.

2. That no difficulty was experienced by the telegraphists in the management of the tuning forks and phonic wheels.

It should be remarked that the weather was fine and dry during the experiments. It was also necessary to clean frequently the sliding contacts of the phonic wheel.

(Sign.) GREDSTED, *Acting Superintendent.*
C. A. PETERSEN, *Superintendent.*
HOEG, *Acting Superintendent.*

When the synchronism had thus been maintained for about three weeks the instruments were removed, and as the telegraphic traffic in Denmark is so small that not a single synchronous multiplex instrument existed, and there consequently was no other synchronism in Denmark which could be replaced by mine, I instructed an agent in Copenhagen to put himself in communication with experts abroad, through whom it could be brought into practical use. I thus came into contact with some American speculators. These seemed to have much confidence in the invention, but they did not appear to have been very fortunate in the choice of electricians to whom they entrusted the investigation of the matter. In the course of the winter, between 1880 and 1881, they seemed to have tried in vain what had proved an easy task to Danish telegraphists, so that one of the speculators wrote from Baltimore in 1881 :—"It would appear to me that the Americans whom we had engaged and who were supposed to be such eminent men, are possessed of considerably less theoretical knowledge than an ordinary telegraph operator in Scandinavia." The end of all this was that I, at the speculators' request in June, 1881, left for New York to start the synchronism. This I accomplished without difficulty, and the speculators now only wished that the American electricians should come and see for themselves, but—what the reason was I never found out—day after day passed without any electrician calling upon me. Having waited in vain for more than a fortnight I determined to return home, when just an hour or so before the departure of the Atlantic mail steamer, and when I was engaged in explaining the matter to the speculators themselves, a gentleman arrived, who was introduced to me as Mr. Callahan, electrical engineer. I showed him the installation and he had nothing to say against it.

A year elapsed in which a correspondence was carried on, partly on technical questions, especially as to the most advantageous method of utilising the synchronism, and partly on commercial, in which I from time to time prolonged the period during which the speculators had the matter in hand. The last days of grace I had given them expired on the 31st of August, 1882, but just at that date an offer was made me by a Mr. Fred. P. Jones, through the American Consul in Copenhagen, and although the period named above had expired, I determined out of regard to the speculators to offer them the invention once more. This I did first by telegraph and afterwards by letter, but I never received any reply, which circumstance was explained by the fact that Mr. Jones was acting in concert with them. A bargain was then arranged for my patent in the United States. This patent was only the patent for the phonic wheel, not for its synchronism, but I undertook to inform Mr. Jones of what more I had invented and possibly might invent with regard to this subject, so

that he might patent it in America. Mr. Jones, on the other hand, promised to send me particulars of any improvement, which he might make, so that I could patent them in Europe.

My patents in Europe for the phonic wheel had at that time become void owing to my inability to pay the yearly fees required in several countries. In April, 1881, I had, however, invented an *improved synchronism* by means of the phonic wheel (of this I shall speak in the next article), and I determined to take out a patent in most European countries for this. Simultaneously, I sent Mr. Jones a copy of my patent and specifications, so that he might secure it for himself in the United States. He acknowledged the receipt of my letter on the 8th of November, 1882, but instead of either restricting himself to America or buying my rights in Europe, the Standard Electric Manufacturing Company, over which Mr. Jones presided, attempted to secure the invention in Europe without paying anything for it. It was, no doubt, known that my patent rights for the phonic wheel had expired, and it was therefore only necessary to make it appear that one of the company's staff had invented an improved synchronism, which could be patented also in Europe.

About a year after Mr. Jones had received information of my improved synchronism, he requested me to authorise him to take out a patent in the United States to secure certain rights which were not stipulated in the original patent for the phonic wheel. This was in reality only a description of my old synchronism, and I considered this request of Mr. Jones a very peculiar one; but having transferred all my rights in the United States to him, I thought I was bound to comply with his request, which I accordingly did. I reminded him, however, of the fact that the new synchronism was better, so that it was more important to him to patent that in the United States. This he did, *not*, however, *in my name*, but in that of Patrick B. Delany, and patents were secured on October the 9th, 1883, essentially based on the same as my improved synchronism. In *the name of Paul La Cour a patent was taken out in the United States for the old synchronism, dated the 22nd July*, 1884. It would thus appear to all who examined the patents in the United States, that La Cour on the 22nd July, 1884, used the old method, and consequently could not have any connection with the improved synchronism. This proceeding has probably made many of Delany's countrymen look upon him as the real inventor of the improved synchronism, and with this as starting point it has been easier to cause certain Telegraph Administrations in Europe to have the same view. In a following article I intend to speak of the history of the improved synchronism.

(*To be continued.*)

THE WESTINGHOUSE ALTERNATING SYSTEM OF ELECTRIC LIGHTING.

IT is not yet two years, writes F. L. Pope in the New York *Electrician and Electrical Engineer*, since the first plant for electric lighting from a central station, making use of a system of distribution in which alternate currents of high potential are converted by induction into consumption currents of low potential, was established in the United States by William Stanley, jun., now electrician of the Westinghouse Electric Company, of Pittsburg, Pennsylvania. A comparatively short experience with this plant was sufficient to demonstrate its many advantages over direct current systems with lamps arranged either in multiple arc or multiple series—or, as Prof. Forbes prefers to say, parallel or parallel series—having either two or three mains or distributing wires, which had, up to that time, been in universal use in this country for incandescent lighting.

Not only does the alternating system in its present form dispense with the complicated apparatus of feeders, regulators, and the like, pertaining to the old systems, and with the accompanying multiplicity of wires at the central station, but it admits of a more simple and effective construction of the dynamo-electric machine, and what is of more importance, the plant as a whole may be installed at a vast saving in first cost, which is due principally to the comparatively small amount of copper required for the main conductors. The operating expenses are also materially reduced, as the conversion system has been found by experience to be capable of giving more light per horse-power, or per pound of coal consumed, than the direct system.

It is in lighting from central stations that the advantages of the alternating system are most strikingly manifested, and it is accordingly not a matter of surprise that the growth of the business of the Westinghouse Company in this particular field during the past year has been quite unprecedented, the number of stations completed and in operation at the present moment being no less than 27, equipped with more than 75,000 C.P. of incandescent lamps.

The alternating system of the Westinghouse Company is based upon the well-known secondary generator system of Messrs. Gaulard and Gibbs, which was first commercially introduced in London in 1883. Although the fundamental principles of the Gaulard-Gibbs system have been retained in the Westinghouse apparatus, the manner in which these principles are applied has been considerably modified, while most of the details have undergone a radical and complete transformation at the hands of many skilful and intelligent inventors, engineers, electricians and mechanics, the results of whose researches and labours have been utilised by the Westinghouse Company. Especially important in this connection has been the work of William Stanley, jun., one of the most talented of the younger electricians of the country, who has been connected with the company from the time of its first organisation, and whose labours in developing and perfecting the present highly efficient methods and apparatus are deserving of special recognition.

While the ordinary system of direct distribution with lamps arranged in parallel is undoubtedly the most suitable for small isolated installations, both theory and practice have shown that except in very special cases, any considerable extension of the territorial area to be lighted necessarily entails an extravagant expense, either in installation or in subsequent operation, or both. If too small a main conductor is used with a view to economy in the cost of copper, the amount of energy wasted in heating the conductors becomes enormous; if, on the other hand, too large a conductor is employed, then capital is uselessly buried. A certain size should be selected with a view to offsetting one of these sources of loss against the other, in such a manner as to arrive at the maximum economy which circumstances permit. The ingenious three-wire system of Hopkinson and Edison was regarded at the time of its introduction as an important improvement, as it effected a considerable saving in the quantity of copper required in any particular case, and thus correspondingly extended the area of profitable station lighting. The question as to the actual extent of this saving gave rise at one time to much discussion, but Prof. Forbes has shown by computations apparently conclusive, that assuming a two-wire system laid down under the conditions of the utmost possible economy in accordance with the law of Sir William Thomson, the maximum saving capable of being effected by the use of a third wire is 25 per cent. In cases where the most distant lamp of the district to be illuminated is not more than 600 or 800 feet from the central station, the parallel or three-wire system is admirably adapted, but as soon as this distance is exceeded the cost of installation begins to mount up at a most alarming rate. A central station can-

not be worked to the greatest advantage unless the engineer and firemen are fully employed, and hence it results that the maximum economy in steam plant, taking into account the cost of attendance, can hardly be reached with less than 1,000 H.P. It is clear, therefore, that the direct system can only be economically and advantageously applied in central station lighting in localities so densely populated as to require, say 10,000 16-C.P.; lamps within a radius of 800 feet; but in any such district space is usually very valuable, and the cost of the real estate required for the station becomes an important, if not a determining factor in the cost of the installation.

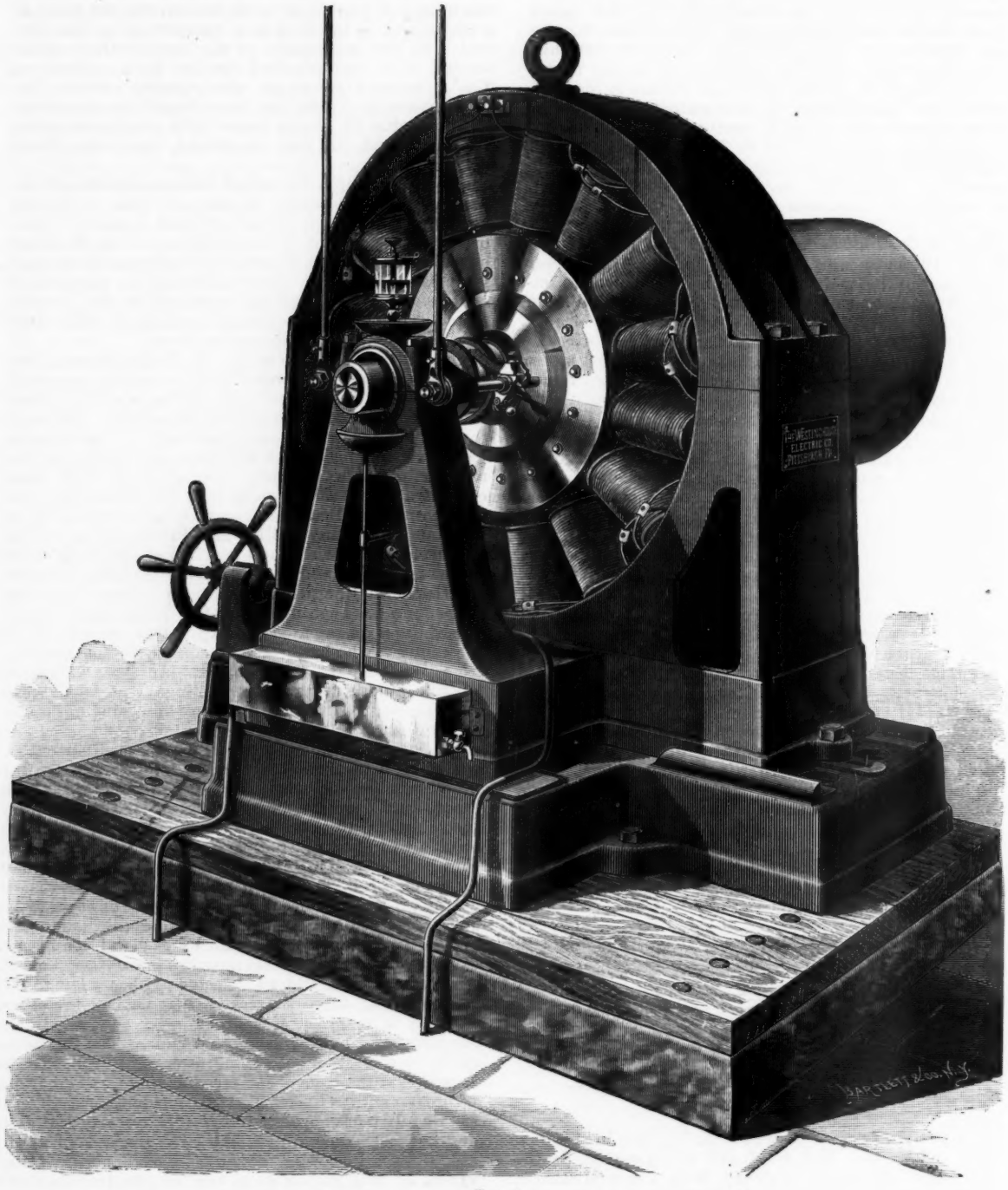


FIG. 1.

The controlling feature in all systems of direct distribution in which the lamps are individually regulable, is the resistance of the lamp filament. This is a necessary consequence of the law which governs the production of heat in a circuit traversed by an electric current, first enunciated by Joule, namely, that the heat developed by a current in any section of an electric circuit is in proportion to the resistance of that section.* In every system of electric lighting the problem is simply to develop the greatest possible amount of heat in the lamp filaments, and the least possible in the remaining portions of the circuit. Hence it is necessary to augment the resistance of the filament to the utmost practicable extent, which is effected by making the carbon of as small a cross section and as great a length as is compatible with sufficient mechanical

* Joule, *Phil. Mag.*, 1884, XIX., 263; Tyndall, "Notes on Electricity," § 271, 272, 273.

stability. It has not been found possible to increase the filament resistance of the ordinary 16 candle incandescent lamp, when alight, much beyond 200 ohms,

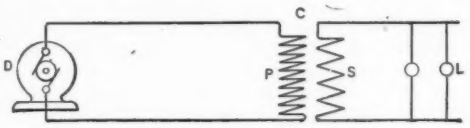


FIG. 2.

without rendering it too fragile and delicate for ordinary use. Being thus limited in this direction, the only course remaining is to reduce the resistance of the remainder of the circuit to the lowest possible point; and in doing this, as already pointed out, it only remains to make the best available compromise between two antagonistic sources of expense, one represented by interest and depreciation calculated upon the first cost of the plant, and the other based upon the cost of power in each particular case, which will vary according as steam or water-power is used, and with the cost of coal. Thus the possible economy of the direct system is, in the present state of knowledge, strictly limited in every direction by natural laws, and can only be increased by increasing the resistance of the lamp filaments, a desideratum thus far sought for in vain. Moreover, should a means be hereafter discovered of increasing the efficiency of the lamp in this particular, its advantages would not be confined to the direct system of distribution, but would be equally shared by the alternating system.

It has long been recognised that the commercial solution of the problem of electrical distribution from central stations must be sought for in the direction of a system of conversion by which the general distribution might be effected at a high potential permitting the use of small conductors, and the local distribution by currents of low potential adapted to supply incandescent lamps of ordinary resistance. Under these conditions the central station may be located at any convenient point where land is cheap, and where power can be economically obtained, without reference to its distance from the centre of consumption, and the station may be of any size, so that all the works may be concentrated in one place as they are in gas distribution. Apparently all these conditions are successfully met by the alternating system, a circumstance due for the most part to its great flexibility. However great may be the area over which the system is extended, each lamp may be lighted, extinguished or regulated, without interfering with others, while the consumption of fuel remains proportional to the number of lamps alight, whether few or many.

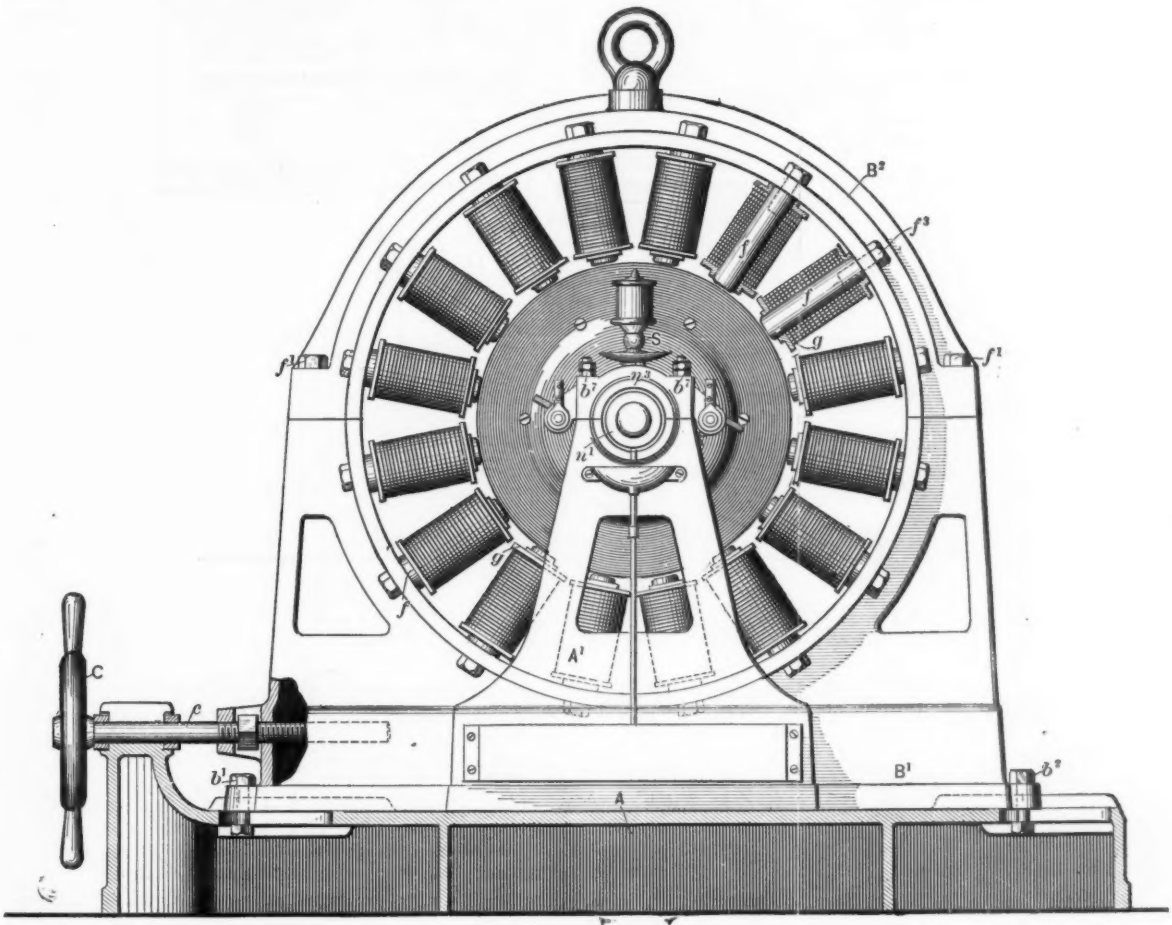


Fig. 3

The essential features of the Gaulard and Gibbs system are, first, a dynamo-electric generator producing alternating positive and negative currents of high potential, which are sent through a main circuit extending to the point of distribution; second, a reversed induction coil, that is to say, one having a greater number of convolutions given to its primary than to its secondary conductor; and third, electric lamps included in the closed secondary circuit of the induction coil. The general organisation will be understood by reference to fig. 2, in which D represents an alternate current dynamo, C an induction coil having a greater number of convolutions in its primary than in its secondary wire, and L an electric lamp. The extent to which the potential is reduced in transferring a given amount of energy

from the primary to the secondary circuit depends mainly upon the ratio of the number of convolutions of the primary to those of the secondary. Thus, for example, if it were required to reduce the potential from 200 to 100 volts, it would be necessary to so construct the induction coil that the number of convolutions in the primary would be twice as great as the number in the secondary, and so for any other ratio of reduction. Such an induction coil has been termed by Gaulard and Gibbs a secondary generator. In the Westinghouse system it is more usually termed a converter.

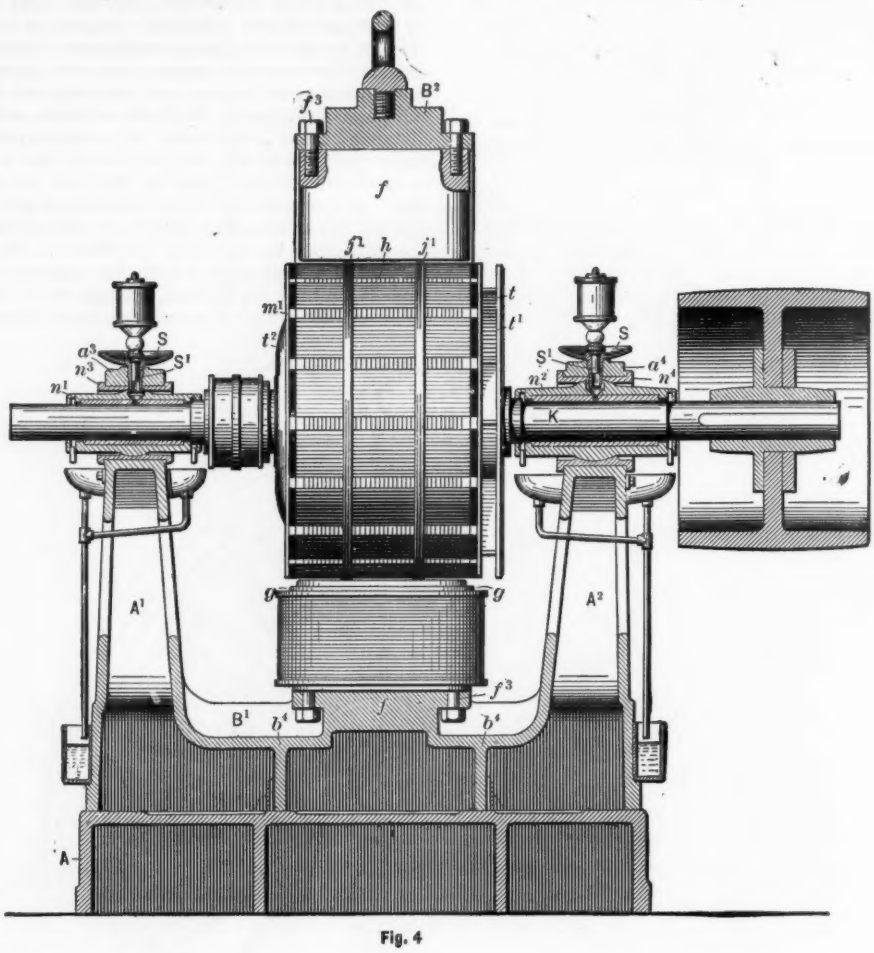


Fig. 4

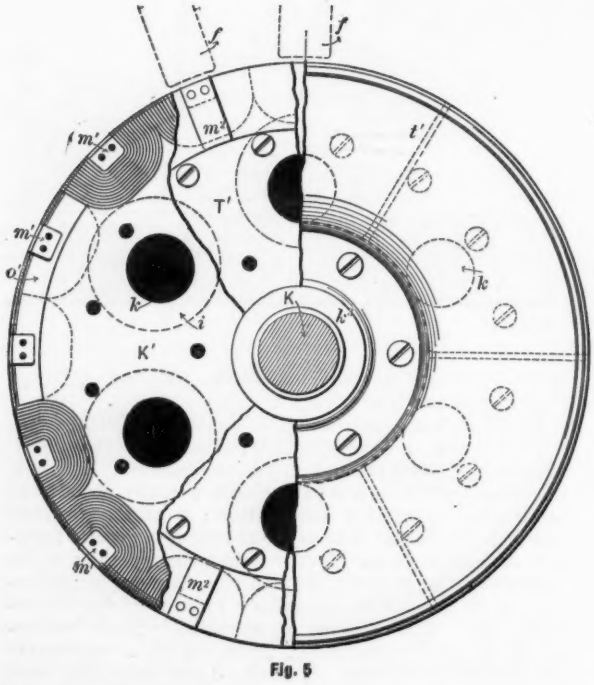


Fig. 5

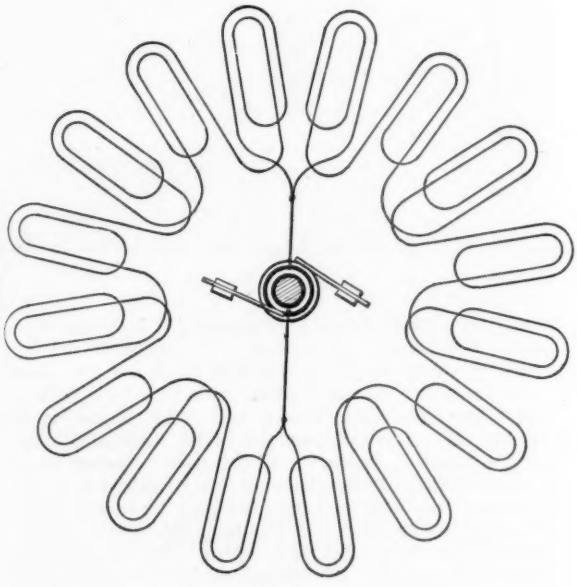


Fig. 6

The potential ordinarily employed in the main circuits of the Westinghouse installations is about 1,000 volts, and that in the lamp circuits 50 volts, the ratio of conversion being, therefore, as 20 to 1. The action of the apparatus will be readily understood in view of the foregoing explanation. The dynamo-electric machine, D, sends out rapid alternations of positive and negative polarity of high potential, and these induce other alternations of current of corresponding rapidity of succession, but of lower potential and increased quantity, in the secondary circuit of each converter. The rapidly alternating current has precisely the same heating and illuminating effect upon the filament of a lamp as the direct and continuous current, although experience has shown that the life of the lamps is considerably greater with the alternate than with the direct current.

The dynamo constructed by the Westinghouse Electric Company for use with this system, was especially designed for this service by Mr. Stanley, and is of the separately excited type. It is at present manufactured in three sizes; No. 1 having a rated capacity of 650 16 C.P. incandescent lights, and Nos. 2 and 3 having a rated capacity respectively of 1,300 lights and 2,500 lights. The engraving, fig. 1, is an excellent representation of the external appearance of the No. 1 dynamo.

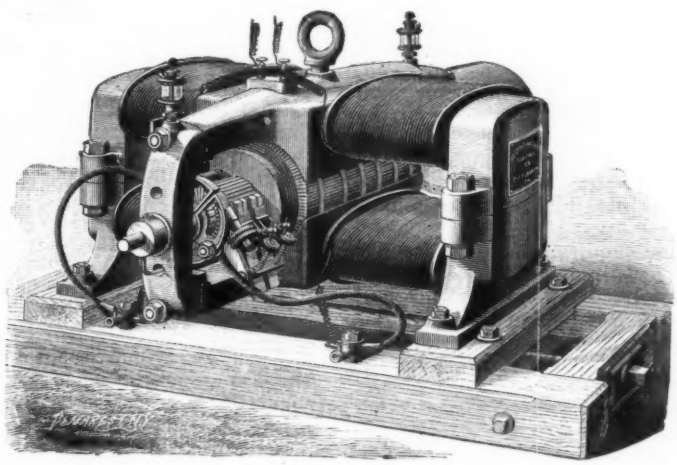


FIG. 6A.

The details of the construction of the machine will be best understood by reference to the sectional drawings, figs. 3, 4 and 5. The foundation of the machine is a heavy cast iron bed-plate, A, having lateral projections upon which the standards, A^1 and A^2, of the armature shaft, K, are supported. These standards are in an integral portion of a single casting, B^1, which rests upon the bed-plate, and is held in position by bolts, b^1, b^2, passing through slotted holes, by the aid of which the lateral position of the entire machine may be adjusted by the hand wheel, C, and adjusting screw, *c*, an adjustment which is necessary when several machines are belted to a single driving-shaft. The cores, *f*, *f*, of the 16 inwardly projecting field magnets surrounding the armature are fixed to a circular yoke, the lower half of which is formed by the casting, B^1, while the upper half constitutes a separate piece, B^2, the two parts being bolted together at, f^1, f^1. The field magnet coils are each wound separately, and afterwards slipped over the pole pieces, and secured in position by screws, *g*.

The armature is cylindrical in form, and is made up of a great number of discs of thin rolled iron placed side by side and insulated from each other by paper. Each plate is stamped out with holes as indicated at *i*, *i*, which serve to cool the armature when running as well as to diminish its weight. In putting the armature together, the holes in the several plates are made to register, so that they form openings extending through the entire length of the cylinder. The discs are clamped together by thick end plates or heads, K^1, K^1, perforated with ventilating holes, *k*, *k*, and provided with reinforcing plates, l^1, l^2.

The armature coils are wound as follows: Non-magnetic plates or strips are secured to the periphery of the armature, at the ends of which are overhanging plates, m^1, m^1, secured to the ends of the armature. The wire is then wound across the face parallel to the axis, and over the corner of the armature, passing around the insulating strips and under the ends of the plates, m^1, filling the spaces between them. In order to shield the wire from the edge of the plates, and to avoid bringing the binding plates to the corner of the armature, rings, o^1, o^2, are fixed at the edges of the armature, flush with its periphery and having their corners rounded so as not to produce too sharp an angle in the wire. In order to more effectually insulate the wire from the body of the armature, the surface of the latter is covered with sheets of mica, and again after the wire is in position, the whole is covered with mica. The parts of the armature are secured by belts of wire, j^1, wound circumferentially.

In the larger machines, instead of winding the armature wire in a continuous circuit, it is divided in parallel in such a manner as to effectually separate the points of maximum and minimum potential. This method of winding is shown in diagram fig. 6, and needs no detailed explanation. The smaller, or No. 1 machine, is usually wound in a continuous circuit.

The journals of the armature shaft are of the type known as "ball bearings," which serve to centre the armature automatically. These are designed in a very convenient manner, by making the ball bushes, n^1, n^2, separate from the split bushes, n^3, n^4. The oil pipe, s^1, extends through the upper section, n^3, of the split bush and into the section, n^1, of the ball bush, and thus serves to prevent the latter from revolving.

The exciter employed for the field circuit of the Westinghouse dynamo is an ordinary Stanley direct current shunt-wound dynamo of the pattern shown in fig. 6a.

The weight of the No. 1 alternate machine is 5,000 pounds; No. 2, 7,550 pounds, and No. 3, 13,500 pounds.

The first two are run at a normal speed of 1,650 revolutions, and the latter at 1,175 revolutions per minute. The electromotive force ordinarily employed in the main circuit is from 1,000 to 1,100 volts. Not more than an equivalent of 2 per cent. of the total energy developed in each machine is consumed in energising the field.

The induction apparatus, commonly called the converter, is ordinarily made in three sizes, respectively adapted to supply 40, 30 and 20 50-volt incandescent lamps of 16 C.P. each, these being the dimensions generally called for in practice. Other sizes, however, are made, some having a capacity as small as 10 lights and others as large as 80 lights. A 40-light converter

contains about 85 pounds of iron and 25 pounds of copper, so that the total weight of metal in this converter is less than 3 pounds per lamp, while the same proportion holds good with trifling variation in the larger and smaller sizes. In the converters as now made, the efficiency of electrical conversion exceeds 95 per cent., when the potential is reduced from 1,000 volts in the primary to 50 in the secondary.

(*To be continued.*)

SHOCKS FROM ALTERNATING CURRENTS.

By G. L. ADDENBROOKE.

THIS subject, which has always been an interesting one physiologically, has now become a question of daily increasing commercial importance, owing to the tendency to use higher and higher voltages in electric lighting and the transmission of power, and to the success which has attended the employment of transformers in connection with alternating current dynamos for lighting both here, in America, and on the Continent.

Statements, more or less positive on the subject, are current in the text books, have been and are being made constantly by various authorities, and we have in addition more or less satisfactory accounts of shocks which have been received by various persons, and, lastly, the records of accidents, including some fatal ones, which have happened owing to the action of the current.

It is with a view of adding, if possible, to the general experiences in this matter and with a desire to clear up some misconceptions that I propose to take up my parable.

In answer to the natural enquiry, what qualifications or experience I possess, entitling me to speak on this subject, I may state that besides the experience and knowledge I have gained from other sources, I am acquainted with nearly all that has been done at the large installation at the Grosvenor Gallery from the first, and further, that from the beginning of last November to the end of July, I was, amongst other things, responsible for the whole of the circuits and the installations in private houses, public buildings, &c., supplied from this centre. These installations amounted to about 60 in number, and are supplied by four separate circuits, extending over an area of, perhaps, a couple of square miles, while the two extreme opposite points are distant nearly a mile and a half from one another.

Now, as is already known in the scientific world, the tension of the main or primary current which has proceeded from the engine-room at the Grosvenor for the last year is 2,500 volts alternating.

In dealing commercially with a current of this intensity, and of a quantity sometimes sufficient to incandesce over 2,000 lamps *at one time*—of course there are very many more than this number of lamps on the circuit—it may readily be conceived that phenomena are met with, and effects seen and producible at will, which so far it has not fallen within the province of the majority of electrical engineers to experience or observe.

In what I am about to say, I propose to limit myself to the effects of the current on the human body under circumstances likely to arise in carrying out work in connection with such circuits.

And firstly, I would remark that when everything is in parallel as at the Grosvenor, the risk of anyone interposing himself directly in the circuit, as has happened in series working, or of anyone laying hold of both mains at once, and so forming a bridge across the circuit, seems very slight indeed. At any rate, no such accident has so far happened, and even if one should happen, I am by no means prepared to assert that the result would undoubtedly be fatal; indeed, I rather incline to the opinion that if the subject of the shock were healthy, and the circumstances under which he received it were favourable, the chances are he would survive. He would, I think, have about as good a chance of life as a man who brought a naked light near the orifice of a 3 or 4-inch gas main with the pressure on, a mishap which has occurred before now.

The class of shocks generally met with in practice and to be dealt with here, are those caused by touching a main directly, or some more or less conductive substance in contact with a main, a current passing owing to the difference of potential set up either through a defect in some other portion of the mains or to a general leakage over the system. And here it may be parenthetically remarked that with mains extending for many miles with numerous branches, terminated by cut-outs, switches and transformers, however high the specific insulation of any given section or piece of apparatus may be, yet, taking the whole circuit—at any rate, in damp and foggy weather—the *actual* insulation cannot be other than only moderate, diminishing with the extension of the circuits.

It will be readily granted by engineers that in central station working, however great the care and provision of the engineers in charge, occasional shocks must be experienced, owing to carelessness or thoughtlessness of workmen, inadvertence, and other causes.

The writer himself received one, which was reported in this paper (though without his previous knowledge), not exactly as it happened, but still with sufficient correctness for the end now in view.

The primary effect of the passage of the current through the body is, of course, to contract the muscles. The amount and persistence of this contraction depend on the quantity of current flowing, or, as it is usually designated, "the intensity of the shock," and varies from a simple twitching of the limbs to complete and intense contraction or rigor of apparently every muscle in the body. In this latter case, the current completely supersedes the action of the mind over everything capable of contraction or movement. Consciousness, however, is apparently rarely, if ever, lost, though the "subject" may be entirely unable to make any motion, cry out, or do anything to help himself. If aid is not near, such a state may be maintained for some time. On release from such a position by extraneous aid or natural causes, the subject is usually dazed, but if at all unconscious, soon recovers completely, and experiences no further functional disturbance than the debility and nervousness naturally following such a severe strain on the system.

About three months ago a man working under me, while making some alterations to a customer's branch on a pole, received such a severe shock as I have described above, and, moreover, partly in consequence of it and partly through the stupidity of another workman, who quite lost his head while trying to extricate his mate, they both afterwards fell a considerable distance on to and through a tiled roof. A broken tile gave the one who had received the shock a very severe cut some inches long on the back of the head, and naturally he was also much bruised and shaken by his fall. He was taken to the Middlesex Hospital, his wounds dressed, and put to bed. Besides the scalp wound he had a bad burn between the thumb and forefinger of the left hand, as if a red hot poker had been laid on the spot and allowed to remain a second or two before being taken away. I detailed all the circumstances to the house surgeon, who kindly undertook to examine the man carefully to see if his nervous system was at all affected. Nothing abnormal, however, could be discovered about the heart's action, nor were there any other secondary symptons. The cut healed rapidly and naturally, the man was out of the hospital in a few days, and soon went off to the seaside to recover his somewhat disturbed equanimity.

I could give details of two or three other cases in which even severer shocks have been received than this one, but the results electrically were much the same as in the above instance.

No doubt a strong enough current can be passed through the body to cause death; deaths have happened

in this way; but if the shock is not sufficient to cause instantaneous collapse, apparently the body can bear the strain of the continued passage of the current for some time. How long will, of course, depend on circumstances; but I think there is enough evidence to show that death, if it resulted, would not be due directly to the effects of the current, but to the paralysis of the involuntary muscles controlling the action of the lungs and heart, caused while it lasted. For as there is no doubt that the current causes intense contraction of all the voluntary muscles, so it does not appear why there should be any exception in the case of the involuntary ones. Death, therefore, in such cases is probably preceded by a series of states nearly analogous to what occurs in drowning, when death ultimately results from the inability of the lungs to continue to perform their proper functions, owing to their being filled with water instead of air. The only difference is that in drowning the action of the lungs continues, but is of no effect, whereas under the influence of the current the action of the lungs probably ceases altogether.

As artificial respiration is a most effective means of resuscitating people apparently quite dead from drowning, so analogy would point to its probably being the most effective way of restoring anyone in the same condition after receiving a severe shock. It seems to me, further, that the man who had received the severe shock would have this in his favour, that his lungs would still remain in their normal condition, and not be partially choked with water, as they would have been had he been nearly drowned instead.

This view of the physiological effects of currents of high potential is gaining ground, and has already been more or less fully stated elsewhere. From personal observation myself, and from all I have been able to gather by inquiry and reading, I am convinced that it is substantially the correct one.

Turning now from the action of the current on the living body as a whole, it may be worth while considering its action locally on the parts of the body where it enters and leaves.

If the contact is good, that is, if it consists of a good area, say of over a couple of square inches of fairly moist skin, pressed with moderate firmness against a metallic body or other good conductor, then no visible injury may result. For instance, a man will often get burnt about the hands, but his feet, by which the current leaves, are either unaffected or else only slightly reddened or inflamed. Burning of the hands or other parts of the body will occur when there is imperfect contact, arising either from imperfect contact of the body with the conductor or from the body while in a position to form a good conductor coming in contact with a bad or semi-conductor, such as a dirty or carbonised surface. The burning is caused by the absolute setting up of an arc.

For instance, a man had hold with one hand of an iron bracket fixed in a wall to support a transformer; inadvertently he caught hold of the bare end of a lead, carrying the primary current with the other; he could not release himself, but was pulled away from his position by those standing by. It was found that, though not otherwise injured beyond a considerable shock to the system, his hands were badly burnt.

Standing on a dry floor and touching one of the primary conductors, does not seem to have any other action than that of exciting an unpleasant sensation, though it is not an experiment to be too frequently or incautiously tried.

So much for the danger of alternating currents of high potential; that they are dangerous there is no doubt, but the danger has been exaggerated. Dealing with them is, I am convinced, not more dangerous than many other engineering operations in which hundreds of men daily engage, though owing to our inexperience and the natural fear we have of anything undefinable, they at present may seem so. I see that they are recognising this in America, and that they are now beginning to manipulate alternating circuits of 1,000 volts tension with considerable confidence.

To show what may be done in this direction, I may be perhaps permitted to mention that during the Jubilee week, in order to join up a new customer to the Grosvenor circuit, I was able by taking proper precaution, personally to take off the insulation from the mains in two places, clean the copper conductors, splice and solder the two branch leads to the mains and afterwards cover the joints with India-rubber tape and solution in the orthodox manner, the full tension of 2,500 volts being on the mains all the while.

Owing to its being the first time the operation was performed, one had greater difficulties and disadvantages to contend with than would be the case in doing the same thing again; in fact, I was obliged to and did freely handle the bare conductors with my fingers, which were only protected by leather gloves. I could feel a slight tingling sensation whilst actually in contact with the bare copper, and a slight spark passing to one's fingers was visible. Once, owing to the over-eagerness of a workman, I received a moderate shock, but otherwise suffered no inconvenience, and was able to demonstrate at any rate to my own satisfaction, that jointing with the current on could be done after a few more trials as a matter of business and daily routine.

SELF-INDUCTION AND ITS MEASUREMENT.

By E. C. RIMINGTON.

(*Continued from page* 312.)

Again, if r is very small compared to D, x_2 is very nearly equal to x_1. So that we have finally

$$L = r \cdot \frac{P}{2\pi} \cdot \frac{d_1}{d_2}$$

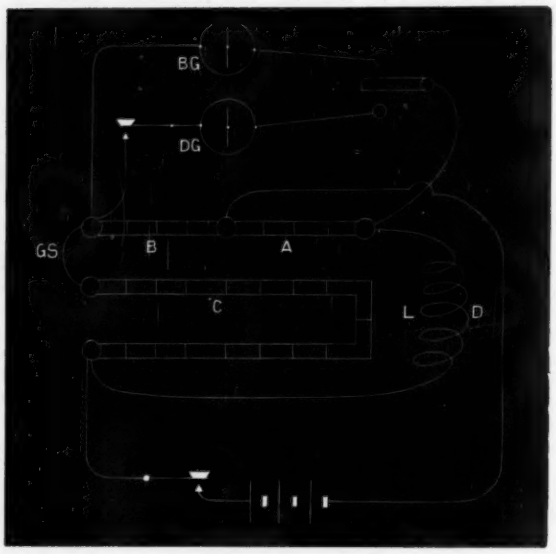
If accuracy is required the damping of the needle due to the air and the effects of the shunts A + B and C + D must be taken into account; if λ be the logarithmic decrement of the needle when connected up to the bridge.

$$L = r \cdot \frac{P}{2\pi} \cdot \frac{d_1}{d_2} \cdot \left(1 + \frac{\lambda}{2}\right)$$

It is not necessary that the resistance r be added to the arm, D. It might, equally well, have been added to, or taken from, the arm, C, and this will in general be the most convenient. In this case the formula will become $L = \frac{A}{B} \cdot r \cdot \frac{P}{2\pi} \cdot \frac{d_1}{d_2}\left(1 + \frac{\lambda}{2}\right)$. A convenient method of altering the resistance of C, particularly when it is small, is by putting a high resistance, R, in parallel with it, then the value of r will be $\frac{C^2}{C + R}$. Several alternate observations must be made of the throw, d_1, and the deflection, d_2, to eliminate any error due to the polarisation of the battery, and great care should be taken to obtain a perfect balance in the first instance; this may be done by the insertion of a piece of German silver or platinoid wire in the arm, C, its length being varied as required. If we have a resistance, R, in parallel with C, an exact balance can be obtained by adjusting R, and the increase of resistance by removing R. It is advisable to have a check coil fixed behind the ballistic galvanometer, so as to be able to bring in quickly to rest when obtaining the balance and making observations on the permanent deflection, and better still, to have a second galvanometer, more or less dead beat, which may be switched in, in place of the ballistic to obtain the balance. If the coil whose coefficient of self-induction is to be measured contains an iron core, the battery must be reversed, instead of its circuit being made and broken, on account of the effect of residual magnetism; this will about double the throw, so that the formula will become:—

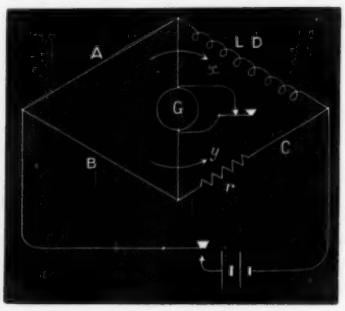
$$L = \frac{A}{B} \cdot r \cdot \frac{P}{4\pi} \cdot \frac{d_1}{d_2}\left(1 + \frac{\lambda}{2}\right).$$

This remark applies also to all the methods to be described, with the exception of Mascart and Joubert's and Thompson's.



Ayrton and Perry's Method.

In this method, by means of a suitable commutator, the battery circuit is closed, the galvanometer circuit is broken, or the galvanometer short circuited, the battery circuit is then opened and the galvanometer circuit closed or the galvanometer short circuit removed. This cycle of operations is continually repeated, and its effect will be to give the galvanometer needle a



series of impulses due to the E.M.F. of self-induction (supposing a permanent balance to be maintained); if these impulses succeed each other at a rapid rate compared with the time of swing of the galvanometer needle, they will result in producing a permanent deflection. This latter can be neutralised by increasing the resistance of the arm, C, by a certain amount, r, which will obviously be greater the faster the impulses succeed one another. Let the above-mentioned cycle of operations be made by the commutator N times per second; if the commutator be a revolving one, N will be the number of its revolutions per second. Let the battery and galvanometer circuits be closed at the same time during $\frac{1}{n}$th of a cycle, or $\frac{1}{n}$th of a revolution of the commutator. Or if T be the time in seconds between closing the battery circuit, breaking it, and again closing it, and t the time in seconds during which the battery and galvanometer circuits are closed together $T = \frac{1}{N}$ and $\frac{t}{T} = \frac{1}{n}$.

First obtain a permanent balance in the usual manner so that A C = B D; the commutator should be cut out of circuit to do this. Then insert the commutator and rotate it; increase the resistance of C by an amount, r, and vary the speed of the commutator until a balance is obtained.

The quantity which passes per second through the galvanometer due to self-induction $= p \, L \, x \, N$. Where x is the permanent current flowing through D and p as before,

$$= \frac{1}{C + D + \frac{G\,(A + B)}{G + A + B}} \cdot \times \frac{A + B}{G + A + B}$$

Again, the quantity passing through the galvanometer per second due to the upset of the balance by the insertion of r

$$= p \, y \, r \cdot \frac{1}{n}$$

where y is the average current passing through $C + r$.

But, since there is no permanent deflection on the galvanometer, these two quantities must equal one another.

Therefore
$$p \, L \, x \, N = p \, y \, r \cdot \frac{1}{n}$$

or
$$L = \frac{1}{n} \cdot \frac{y}{x} \cdot r \cdot \frac{1}{N}$$

Again, since the average current through the galvanometer is zero,

$$\frac{y}{x} = \frac{A}{B}.$$

Hence
$$L = \frac{A}{B} \cdot \frac{1}{n} \cdot \frac{r}{N}$$

or
$$L = \cdot \frac{A}{B} \cdot t \, r.$$

If A = B
$$L = \frac{1}{n} \cdot \frac{r}{N} = t \, r.$$

In practice Messrs. Ayrton & Perry prefer to short circuit the galvanometer instead of breaking its circuit, and they give a full mathematical investigation of the effect of the dying away of the current in it when short circuited due to its self-induction. On account of this effect the formula obtained differs very slightly from the one just obtained, but the difference is so small that it is neglected. For a full account of the investigation see ELECTRICAL REVIEW, Vol. XX., page 433. The speed of the commutator must never be too great to allow the currents x and y to attain their permanent values.

Mascart and Joubert's Method.

Place the coil whose coefficient of self-induction is to be measured, in series with a resistance possessing practically no self-induction, and whose value is greater than the resistance of the coil. Pass an alternating current of known period, T, through the two. With a voltmeter, capable of being used for alternating potential differences, measure the potential difference at the terminals of the coil, and also that at the terminals of the resistance; let the deflections produced on the voltmeter be d_1 and d_2 respectively. Now since the current through the two coils is the same, their potential differences will be proportional to their apparent resistances; so that, if R be the resistance of the coil, and R_1 that of the resistance possessing no self-induction

$$\frac{\sqrt{R^2 + \frac{4\,\pi^2\,L^2}{T^2}}}{R_1} = \frac{d_1}{d_2}.$$

Hence
$$L = \frac{T}{2\,\pi} \sqrt{\left(R_1 \frac{d_1}{d_2}\right)^2 - R^2}.$$

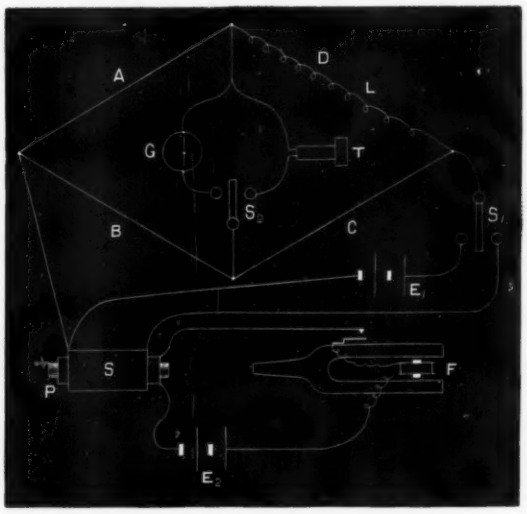
In making this test a high resistance Siemens electrodynamometer may be used for the voltmeter, as in this case its self-induction will not affect the result, since the rate of alternation remains the same for both observations, and the ratio of the potential differences

is all that is required. If d_1 and d_2 are the readings of the torsion head of the dynamometer

$$L = \frac{T}{2\pi}\sqrt{R_1^2 \cdot \frac{d_1}{d_2} - R^2}.$$

Thompson's modification of Mascart and Joubert's method.

G is an ordinary galvanometer, T a telephone, P the primary, and S the secondary coil of an induction coil, whose "break" is screwed up. F is a tuning fork, of known frequency of vibration put in the circuit of the primary coil and a battery E_2. S_1 and S_2 are two way switches, and E_1 the battery to enable the resistance of D to be measured in the usual manner. Let this be done, and suppose its resistance to be R. Move



the switches S_1 and S_2 so as to put the secondary coil in the place of the battery and the telephone in that of the galvanometer. Start the tuning fork interruptor, F, this will send an intermittent current of known frequency through P, and will induce in S an alternating current of the same period which will approximately follow the law of sines. Adjust C so as to obtain a balance under these conditions, which will be indicated by the sound in the telephone being a minimum, let the apparent resistance of D be R_1

Then

$$R_1 = \sqrt{R^2 + \frac{4\pi^2 L^2}{T^2}} = \sqrt{R^2 + 4\pi^2 n^2 L^2};$$

where n is the frequency of the tuning fork.

Hence

$$L = \frac{\sqrt{R_1^2 - R^2}}{2\pi n}$$

(To be continued.)

UNDERGROUND WIRES.

AT the late meeting of the American National Electric Light Association the question of the insulation of underground wires formed one of the subjects brought forward for discussion. As electric lighting and the employment of electricity as a motive power have made such enormous strides in the United States, it would have been supposed that the subject contained elements of especial interest to American engineers. We must confess to have been much disappointed at what we consider was a very meagre exposition of the question.

It appears that the committee appointed to investigate upon the proper insulation of underground wires were unable to carry out any experiments owing to the want of funds. Their labours resulted in the suggestion of certain tests which, in their opinion, should be applied to electric light leads. Our opinion as to the value of these suggestions is somewhat influenced by the following statement which we extract from the report drawn up by the said committee :—

". . . . as it is known, at a voltage of, say, 60 volts, moisture does not seriously interfere with ordinary underwriters' wire, while a somewhat higher voltage will set fire to wood through underwriters' insulation."

In the discussion which took place towards the end of the meeting several gentlemen gave their experiences of underground wires.

At Detroit the Municipality have stopped the laying of underground wires through the city, and the overhead wires have become a terrible nuisance, but no one knows what system to adopt, as everything is in an experimental stage.

At Philadelphia, lead-covered cables were placed in troughs filled up with petroleum residuum. The result seems to be far from satisfactory, as the whole system must be replaced before any more lines are run on the circuit. Here, also, it is complained that only the experimental stage has been arrived at.

In Chicago, Dorsett conduits and lead-covered cables are used. These cables gave so much trouble that at one time they were given up, but have lately been again resorted to, apparently for the want of something better. It is found that a good deal of damage is caused by rats biting through the lead covering.

At Troy, the conclusion seems to have been arrived at that, with the present knowledge of underground work, it would be impossible to satisfactorily employ underground wires.

From Baltimore comes the opinion that the distribution of current by means of underground cables is perfectly feasible, but that it is a too expensive method.

Of discussion, properly so called, there was none, and the foregoing is a slightly condensed account of the entire proceedings relative to the question of underground wires. It is to be remarked that in not a single instance was the nature of the insulating material referred to except vaguely as "the insulation." It is to be regretted that such an opportunity for thoroughly investigating a matter of so great importance should have been neglected, since a representative assemblage (as was the one under notice) would be supposed in every respect to be pre-eminently qualified for such a purpose.

ELECTRIC LIGHT AT THE NEWCASTLE EXHIBITION.

ON Saturday evening Prof. Garnett again lectured on the electric light in the theatre of the Royal Exhibition, Newcastle-upon-Tyne. There was a very large audience, including a great many working men. The lecturer having alluded to recent fires in theatres, proceeded to show how the lights in the Exhibition theatre could be raised and lowered by the introduction of resistances, so as to adapt the lighting to the requirements of the stage. He then turned out all the lights as though an accident had happened to the engine, and immediately lit up two small clusters of lamps which had previously been unobserved, and which were connected with the picture gallery circuit, for which, not only the dynamos, but the engines and boiler were completely separate from the theatre plant. It was then shown that these "panic lights" could be lit either from the stage or the ticket office. On again turning out the lights another switch was turned and a lamp of 1,000 candle-power, constructed by Messrs. Clarke, Chapman, Parsons & Co., of Gateshead, and supplied with current from the south court of the exhibition, illuminated the whole theatre. The power of this lamp was very striking in so large a building. Prof. Garnett pointed

out that with the exception of this lamp all the arrangements for the lighting of the theatre had been carried out by Messrs. J. H. Holmes and Co., of Newcastle-upon-Tyne. He then showed that when a coil of wire was moved near the pole of a bar magnet a current was produced which caused a large disc of light reflected from a mirror galvanometer to move across the stage, and gave a very brief description of the construction of a continuous current dynamo. The arc lamps of Messrs. J. H. Holmes & Co. were then described. These lamps weigh only 8 lbs., and they can be made to burn steadily by a very small current. One of the prettiest exhibits was a small arc lamp constructed by Messrs. Holmes, and placed in series with two small 45 volt lamps, each lamp taking one ampère, so that the arc lamp absorbed exactly the same amount of energy as the two glow lamps together, and the audience were left to compare the light in the two cases. The "diamond arc lamps" employed in the lighting of the gardens by Messrs. Woodhouse & Rawson were then described, and two of the lamps were lit before the audience. These lamps have now been burning in the Exhibition gardens and engine-room for five months with perfect steadiness. An arc light projected on the magic-lantern screen enabled the audience to see the carbons feed and to compare the light from the arc with that from the carbon points. Prof. Garnett then described and exhibited an incandescent lamp of 600 candle-power and an incandescent search lamp of 500 candle-power, used by ships in entering docks or harbours at night. Both these lamps were lent by Messrs. Clarke, Chapman & Parsons. The lecture terminated with a comprehensive description of the turbo-electric generator, constructed by the firm just mentioned. A generator having an electrical output of about 5 E.H.P. was exhibited upon a small occasional table; but the exhibit which attracted most attention was the spindle and armature and one half of the barrel of a large generator having an output of nearly 40 E.H.P. and constructed on the triple expansion principle, the spindle carrying three sets of discs of different sizes corresponding to the pistons of an ordinary triple expansion engine. The action of the generator was illustrated by means of a siren. The arrangement for keeping up a continuous circulation of oil in the machine and the magnetic regulator for maintaining a constant E.M.F. were also described. Through the kindness of Messrs. Woodhouse & Rawson an alternating current from a Gramme machine was conveyed to the theatre and employed in lighting three Jablochkoff candles.

Arrangements have been made for lectures to be delivered in the Exhibition theatre every Monday and Saturday until the close of the exhibition.

BRITISH ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE.

(Specially Reported for the "Electrical Review.")

NEW ELECTRIC BALANCES.

By Sir WILLIAM THOMSON, F.R.S.

(Section A.—Mathematical and Physical Science)
Friday, September 2nd.

THE balances are founded on the mutual forces, discovered by Ampère, between the fixed and movable portions of an electric circuit. The mutually influencing portions are usually circular rings. Circular coils or rings are fixed with their planes horizontal to the ends of the beam of a balance and are each acted on by two horizontal fixed rings placed one above and the other below the movable ring. Six grades of instruments are made, named centi-ampère, deci-ampère, ampère, deca-ampère, hecto-ampère, and kilo-ampère balance. The range of each balance is about 25. Thus, the centi-ampère balance will measure currents of from 2 to 50 centi-ampères, while the kilo-ampère balance will measure currents of from 100 to 2,500 ampères. Since the indications of the instrument depend on the mutual forces between two parts of an electric circuit of permanent form and relative position, they are not subject to the changes with time which are so troublesome in instruments the constants of which depend on the strength of permanent magnets.

The most important novelty in these balances is the connection between the movable and the fixed part of the circuit. The beam of the balance is suspended by two flat ligaments made up of fine copper wires placed side by side. These ligaments serve instead of knife edges for the balance, and at the same time allow the current to pass into and out from the movable coils. The number of wires in each ligament varies from 20 in the centi-ampère to 900 in the kilo-ampère balance. The diameter of the wire is about $\frac{1}{10}$th of a millimetre and each centimetre breadth of the ligament contains about 100 wires.

The electric forces produced by the current are balanced by means of weights which can be moved along a graduated scale by means of a self relieving pendant. Two scales are provided, one a scale of equal divisions, the other a scale the numbers on which are double the square roots of the numbers on the scale of equal divisions. The square root scale allows the current to be read off directly to a sufficient degree of accuracy for most purposes. When high accuracy is required the fine scale of equal divisions may be used and the exact value of the current obtained from a table of doubled square roots supplied with the instrument.

An engine room voltmeter on a similar plan was described. It consists of a coil fixed to the end of a balance arm, suspended in the manner above described, and acted on by one fixed coil placed below it. The distance of the two coils apart is indicated on a vertical scale by means of a magnifying lever and serves to indicate the difference of potential between the leads to which the instrument is connected. The coils of the instrument are of copper wire, and an external platinoid resistance of considerably greater amount is joined in circuit with it. The electrical forces are balanced by means of a weight placed in a trough fixed to the front of the movable coil and weights suited to the temperatures 15°, 20°, 25°, 30°, C., as indicated by a thermometer with its bulb in the centre of the coil are provided.

Two other instruments were described, namely, a marine voltmeter suitable for measuring the potential of an electric light circuit on board ship at sea, and a magneto-static current meter suitable for a lamp counter.

In the marine voltmeter an oblate spheroid of soft iron is suspended in the centre of, and with its equatorial plane inclined at about 40° to, the axis of a coil of fine copper wire by means of a stretched platinoid wire. When a current is passed through the coil the oblate of soft iron tends to set its equatorial plane parallel to the axis of the coil and this tendency is resisted by the rigidity of the suspension wire.

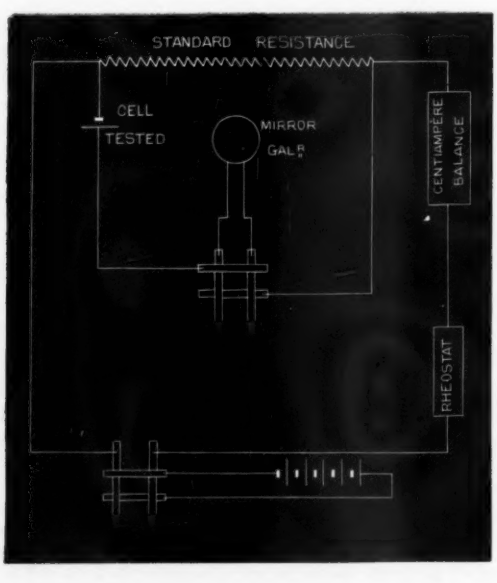
The lamp counter is a tangent galvanometer with special provision for preventing damage to its silk fibre suspension, and for allowing the constant to be readily varied by the user to suit the lamps in his circuit.

ON THE APPLICATION OF THE CENTI-AMPERE OR THE DECI-AMPERE BALANCE FOR THE MEASUREMENT OF THE E.M.F. OF A SINGLE CELL.

By Sir WILLIAM THOMSON, F.R.S.

(Section A.—Mathematical and Physical Science.)
Tuesday, September 6th, 1887.

FOR the purpose of measuring the E.M.F. of a single cell the centi-ampère or the deci-ampère balance is put in circuit with a



battery of a sufficient number of cells, a rheostat, and a standard resistance, in the manner shown in the diagram. The current measured by the balance is then varied by means of the rheostat until the difference of potential between the ends of the standard

resistance is exactly equal to the potential of the cell. This equality is tested by placing the cell in series with a mirror galvanometer or a quadrant electrometer in a derived circuit, the ends of which are connected with the ends of the standard resistance, and observing whether any deflection is obtained by closing this circuit. Suppose, for example, the standard resistance to be 10 ohms, and the current as indicated by the balance 0·108 ampères, when no deflection is obtained on the mirror galvanometer by closing its circuit, the potential of the cell is 10 × ·108 or 1·08 volts. Proper precautions must, of course, be taken to eliminate thermo-electric or other disturbances in the circuit.

The quadrant electrometer may be used with advantage in the derived circuit, when it is important that no current should flow through the cell, but the mirror galvanometer has the advantage of much greater sensibility.

ON INDUCTION BETWEEN WIRES AND WIRES.

By WILLIAM HENRY PREECE, F.R.S.

(Section A.—Mathematical and Physical Science.)

Tuesday, September 6th.

LAST year at Birmingham I pointed out that the electro-magnetic induction between wire and wire upon lines of telegraph extended to distances much greater than was anticipated, and that effects were observed even when the wires were separated by the breadth of England. I was not satisfied with the last experiments made in the north of England. I had reason to believe that they were vitiated by induction and conduction through the network of cross circuits and railway wires in that part of the country, so in October of last year I took the district between Gloucester and Bristol along the banks of the Severn, where it was possible to completely isolate two systems of wire separated by the river Severn for a length of fourteen miles at an average distance apart of 4·5 miles, and where any disturbing cross-inductive or conductive connection was impossible. The circuits on each side of the river could be completed by the earth or by metallic returns passing far inland, in the one case through Monmouth, and in the other cases through Stroud. The experiments made were very numerous, but the results were almost negative. No measurable effect whatever could be detected when primary currents of ·449 ampère strength were intermittently sent by a rapid vibrator or buzzer on each side, though it was just possible to distinguish faint Morse signals. It was quite clear from subsequent experiments that we were on the extreme verge of audibility, and had we been able at the time to increase the strength of our primary current we should have heard louder effects. In fact, I have taken this experiment as a measure of the limit of audibility—a conclusion fully confirmed by subsequent results. The experiments fully justified my conviction that those reported last year as occurring between Newcastle and Carlisle were wrong.

In all the following experiments the primary currents were always of rapid frequency, producing a buzzing sound, which could be easily read when audible, if sent in the Morse code, and received on a Bell telephone.

Two squares of 1,200 yards of gutta-percha covered copper wire, or 300 yards each side, and of a resistance of 15 ohms, were placed 300 yards apart in the Porthcawl Sands in South Wales, and conversation by the Morse code was readily maintained with primary currents of ·226 ampère. Conversation by telephone was impossible. Two other similar squares were subsequently (December) suspended on scaffold poles 15 feet above corresponding squares lying on the sands, which latter were covered with water when the tide was up.

No difference whatever could be detected in the strength of the signals received by induction, whether the space were air or water, or a combination of air and water. The Irish wires on the railway were 150 yards distant from the squares, and the usual disturbance was evident on all the squares, whether under water or not.

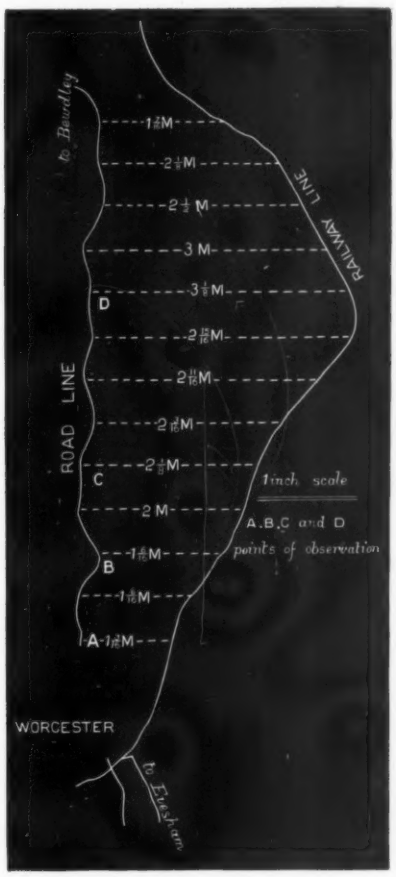
The principal object of this experiment was an endeavour to differentiate any electro-static from the electro-magnetic inductive effect, and the conclusion drawn was that the whole phenomenon was electro-magnetic, for no electro-static effect could be obtained. No doubt with parallel wires on a line of poles, where the distance between wire and wire is far less than that between wire and earth, electro-static induction comes into play, but its effect in the cases investigated was absolutely inappreciable.

This was confirmed by further experiments made with squares of 33 feet sides, fixed three feet apart.

Moreover, it tends to the conclusion that the magnetic field extends uninterruptedly through the earth as it does through the air, and that if the secondary circuit had been in a coal pit it would have been equally evident.

It also accounts for the peculiar disturbance observed in submarine cables when lying near each other as described in my previous paper. I hope to have the opportunity some day of testing the limit of audibility in water. Cables, as a rule, lie too far apart for the purpose. I have made several efforts to get results on our Irish cables; but they lie apart far beyond the limit. Mr. Ash, the superintendent of the Eastern Telegraph Company at Porthcurnow, in Cornwall, joined a telephone to the ends of two cables, one terminating at Lisbon 820 miles away, the other terminating at Vigo, 620 miles away. Signals could be distinctly heard on the telephone from the Brest cable landing about half a mile away, and terminating at Penzance.

We happened during the autumn to be constructing a new trunk line carrying four copper wires from London to the coast of North Wales, and for many miles of its length in different places it ran parallel at various distances to the Great Western Railway. On November 11th, 1886, between Shrewsbury and Much Wenlock, 10¾ miles in length, a wire on the railway was made the primary wire, along which a periodic current of ·08 ampère was sent. Stong signals were received on the copper wires, although they were completely isolated from any possible interference. The frizzling sound due to the ordinary induction from the mixed signals used in ordinary working were also evident, but the separating distance for 8 miles was only one quarter of a mile. Between Much Wenlock and Bewdley for a length of 12½ miles, where the separating distance averaged 1 mile 1,046 yards, the ordinary induction sounds entirely disappeared. On November 28th, 1886, similar experiments were repeated on a system of wires separated and isolated by the River Mersey for a distance of 11 miles. The primary circuit completed by the earth was on the Lancashire side. On the Cheshire side the secondary circuit was completed by a well-insulated metallic loop running inland, and measured 38½ miles in length. Morse signals were distinctly received. The separating distance was 1¼ mile. In February, 1887, the section between Worcester and Bewdley was divided into lengths, as shown in the following sketch :—



A wire on the railway was made the primary, the periodic current being ·12 ampère, but the results were *nil*.* In no case could induction be heard between any of the points A, B, C, or D, or upon the whole length. Resort was again made to squares in a field near Cardiff, removed from all possible interference, and the standard of comparison made was the limit of audibility. This is not an absolute or a scientific standard to use, but it is practical. It depends on the variation of the human ear and the sensibility of the telephone receiver, but as the results recorded were always the conclusions of several persons, and the same telephone receiver was used in all cases, the normal ear may be assumed to have been used, and telephones do not differ much from each other when the same pattern is used. But they are much dependent on surrounding circumstances and extraneous sounds, on slight noises arising from the wind, from the rustling of the trees, from showers of rain, from passing persons or vehicles. The results of these experiments are given in the following table :—

* The limit of audibility in this case was ·66 mile.

TABLE A.

Experiments on Induction at Lisvane, February 2nd, 3rd, and 4th, 1887.

Experiment.	Current in primary. c_1.	Working face of primary.	Working face of secondary. (l)	Resistance of secondary. r_2.	Limit of audibility. x.	Calculated results.
	Ampères.	feet.	feet.	Ohms.	feet.	feet.
1	·69	600	30	700	179	179
2	1·3	600	30	700	257	246
4	·69	600	60	700	585	
5	·69	600	30	700	182	
6	·69	600	30	200	641	641
7	·69	600	60	50	915	926
8	·69	600	90	76	1100	1134
9	·5	600	90	70	1373	1280

The extreme limit of audibility is derived from the Severn experiments, and is taken at 1·9016 miles which would be the case were we operating with one mile of line and one ampère Other conditions remaining the same,

$$x = 1{\cdot}9016 \sqrt{\frac{c_1 l}{r_2}}$$

from which the sixth column is calculated.

On April 10th, when the system along the banks of the Severn was again resorted to, as a primary five wires running on the Midland Railway between Gloucester and Stonehouse were bunched at each extremity, and the secondary was one of the road wires which was parallel with the railway, and at an average distance of one mile, over a length of two miles. This secondary could be joined up at will into sections of one and two miles long, the observations being made in the middle. Under these circumstances the following observations were taken.

TABLE B.

Experiments on Induction, Gloucester and Berkeley, 10th April, 1887

Experiment.	Current in primary.	Length of secondary.	Resistance of secondary including telephone.	Results.
	Ampère.	Miles.	Ohms.	
1	1	1	85	Good.
2	·73	1	85	Somewhat lower than in No. 1.
3	·53	1	85	Slightly lower, but above limit.
4	·33	1	85	Not much distinguishable from No. 3.
5	·22	1	85	Just audible. Taken as limit.
6	·11	1	85	Not a sound.
7	·11	2	112	Faintly heard, but below limit in experiment No. 5.
8	·148	2	112	Somewhat better than No. 7, but still low.
9	·22	2	170	In these experiments the two-mile length was made equal in resistance to twice the mile length, the audible sounds being under these circumstance alike in both wires.
10	·22	1	85	
11	1·0	1	425	Current in primary increased five times, and resistance in secondary in like proportion. Audible limit reached.
12	·44	1	165	Current in primary, and resistance in secondary doubled, and audible limit again reached.
13	·85	1	335	Current in primary, and resistance of secondary increased four times. Limit of audibility again reached.

Having thus obtained the conditions that determine the limit of distance across which induction is perceptible by the telephone, it became necessary to make some careful measurements so as to formulate the law that regulates the observed effects.

Let there be two wires placed parallel to each other for a length, l, and at a distance, d, then whenever the circuit is made in one wire a secondary current, c_2, due to electro-magnetic induction and in the reverse direction will be produced in the other wire, and when the primary circuit is broken a current in the same direction will appear in the secondary. The relation between the primary c_1 and induced currents is given by the formula

$$c_2 = M\, c_1$$

M being a coefficient of induction depending on—

1. The length, l.
2. The distance, d.
3. The resistance of the secondary circuit, r_2.
4. The rate at which the primary current rises or falls.
5. The condition that determines the rate at which the current rises or falls in the secondary circuit.

The following experiments were made to determine these different functions of M. The new General Post Office at St. Martin's-le-Grand is an oblong building, with four convenient corridors or galleries all round the building, along each of which perfectly insulated gutta-percha covered copper wires ·050 inch in diameter were suspended along the wall. The wires were 20 feet apart, and each formed a complete metallic circuit, 250 yards in length, in which any apparatus could be inserted. The building itself is a huge magnetic field in a constant state of perturbation owing to the concentration there of a thousand circuits conveying messages. The consequence was that each experimental circuit was always in a state of disturbance, rendering accurate measurements during working hours impossible and speech out of the question. Nevertheless, it was quite possible to differentiate the sound of the voice from the rest of the noises though 80 feet of space intervened. It being quite evident that no other instrument than the telephone could indicate these effects, and my object being to measure them in absolute measure two wires were suspended around one corridor at a uniform distance of 6 inches apart. After obtaining reading at this distance the space was increased to 12 inches, and, finally, reduced to a distance of ¼ inch.

The primary current ·21624 ampère was obtained from a Daniell battery, and was made uniform in strength in all cases. The secondary currents were read by the throws of a Thomson galvanometer. These deflections were reproduced and measured as is done in measuring condensers. The average results of many experiments come out as follows:—

Inch.		Observed.			Calculated.
·25	...	·004	ampères	...	·004
6	...	·000007	„	...	·000007
12	...	·000002	„	...	·0000018

It will be seen that the law follows the inverse square of the distance, and this is fully confirmed by previous and subsequent experiments. Moreover, it is easy to show that it must be so when we can neglect the influence of the earth. It is well known, and has been fully verified in all these experiments, that the strength of the secondary current will increase directly with the strength of the primary current, and directly as the length of wire under influence within the limits of these experiments. We can thus calculate a useful standard for use.

250 yards of ·21614 ampère, at 12 inches, induced a secondary current of ·000002 ampère in a circuit of 13·27 ohms, or 1 mile of 1 ampère, at 1 mile distance, would induce a secondary current of ·0000000000013, or 13×10^{-13} ampère; and at 2 miles 3×10^{-13} ampère in wires such as were experimented with.

We can write the law thus—

$$c_2 = \frac{c_1\, l}{d^2\, r_2} \times M$$

I intend to repeat these experiments with care to obtain the value of the constant, M, in C.-G.-S. units M = ·005.

The disturbances due to the mixed working currents on our telegraphs cannot be appreciable beyond 450 feet, but those employed in distributing electric light by means of secondary generators must extend to miles unless they are neutralised by the two conductors being fixed parallel and close to each other.

I have not yet been able to make any experiments to determine satisfactorily the influence of retardation and electro-magnetic inertia on this limiting distance.

I erected two wires of iron for a mile alongside the copper wires, but was not able to get any conclusive results. It is, however, quite certain that there is a difference in the effect when the wires are of iron or of copper, and that the distance across which induction is perceptible must reach a limit of length when the resistance and capacity reduce the rate at which the currents rise and fall, and the effects must begin to diminish. Hence the disturbing effects due to short lines are more pronounced than those due to long lines.

This limit of audibility enables us to calculate the current required by a Bell telephone, like that used in these experiments, to become just audible. It is roughly the six ten thousand-millionth of a milliampère, or, in figures, ·0000000000006 ampère, or 6×10^{-13} ampère.

Hence the air telegraphs used in America by Edison, Phelps, and others for communication with passing trains are readily comprehended, and the distances to which disturbances are propagated between telegraphic, electric lighting, tramway circuits easily calculated. The distance through which communication can be maintained between ship and ship, between lightship and shore, between islands and the mainland, between the defenders inside and those outside a beleaguered city, becomes simply a calculation. I have been assisted in carrying out these experiments by Mr. J. B. Chapman, of my own office; by Mr. J. Gavey, of Cardiff, and Mr. J. R. Edwards, of Liverpool, both members of the Society of Telegraph Engineers, and the Post Office engineers in charge of the districts affected, all of them careful and reliable experimenters.

DISCUSSION.

Sir WM. THOMSON said that the current of an ampére produced in one wire produced a certain current in the other, and he wished to know whether that was caused by the sudden stoppage of it.

Mr. PREECE said the prime currents used in all the experiments were intermittent currents of the duration of $\frac{1}{12}$th of a second.

Sir WM. THOMSON: Equal time off and on?

Mr. PREECE: Yes.

Sir WM. THOMSON distinctly understood that 6 times 10^{-13} was the mean square of the current.

Mr. PREECE: That is so.

Sir WM. THOMSON: There is one ampère broken 250 times per second—that is to say, there are 250 periods or breaks per second.

Mr. PREECE: Yes; I did not use reversals in this instance, because they were so extremely difficult to calculate and measure, but I used simply vibrations. There were 250 distinct intermittences in the primary currents.

Sir WM. THOMSON: It is an exceedingly important result, and leads the theory to very correct measurements. Was the result obtained by measurement or theory?

Mr. PREECE: By calculation. The measurements by which the calculations were made were upon the squares at a 4 inch, 6 inch, and 12 inch distance, and from measurements we made to verify these at 15 feet distance, and also upon the limit of the audibility obtained. Others were obtained at a distance of nearly 2 miles, so that the range is very great. The measurements made at 6 inches and 12 inches are accurate measurements of the current. They were verified by the measurements between two squares 15 feet apart, and this current is estimated from the previous measurements made, and on the limit of audibility at a distance of 1·9 miles. We know that at 1·9 miles we just lose audibility in the telephone. Just inside that distance, say 1·6 miles, we are well within the point of audibility.

Sir WM. THOMSON: It is not necessary for me to say anything on the excessive importance of these researches and the applications which Mr. Preece has suggested for them. It seemed as if the telephone had solved the problem of telegraphy without wires; it is exceedingly interesting and important to think that messages can be heard at a mile without any wire whatever connecting the two stations, and I think Mr. Preece deserves our best thanks for having brought this subject before us, and I am sure we all wish to hear more about it. It is a most excellent thing for science that Mr. Preece has taken advantage of the opportunities he has for experimenting on so large a scale, and I hope he will be induced to go on more and more and give us still further results, which cannot but be valuable in practice, besides being exceedingly interesting to science.

ON THE PRODUCTION OF A CONSTANT CURRENT WITH VARYING ELECTROMOTIVE FORCE FROM A DYNAMO.

BY A. P. TROTTER.

(Section A.—Mathematical and Physical Science.)

Tuesday, September 6th, 1887.

Nearly all the earliest dynamos made for practical work were intended to give a constant current for arc lights in series. Few attempts were made to extinguish separate lights; partly on account of the light being generally required for outdoor work, and partly by reason of the contentment with which Americans accept a successful notion without demanding the refinements which are expected in this country.

The problem is, to vary the volts when the external resistance is altered, so that the current may be kept constant.

The best known methods are those of Thomson-Houston, Maxim-Weston, and Hochhausen. These rock the brushes on the commutator by means of automatic arrangements on which considerable ingenuity has been expended, and the results, so far as they are applied to arc lighting, are satisfactory.

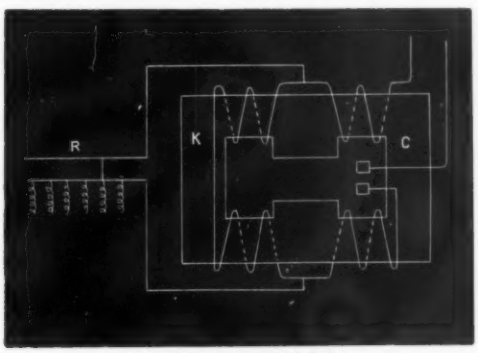
The armatures of dynamos for series arc lighting are, for several well-known reasons, made with less iron and with more wire than those of machines used for other purposes, and a high resistance both of armature and field coils, together with a considerable amount of induction and heating, are, as a rule, inseparable from dynamos for arc lights, and although such proportions preclude the possibility of a high efficiency in the dynamo, it is generally considered that these losses are made up for by the economy of a small conductor, and the simplicity of working with a uniform current. With such armatures, the volts may be reduced by rocking the brushes, and, if the proportions of iron and wire are correct, this will produce hardly any sparking or additional heating.

A constant current is required for several other purposes than for arc lamps, *e.g.*, the Bernstein system of low-volt lamps in series, certain applications of motors, and for electro-deposition with baths in series. For such purposes there would be no advantage in using a small quantity of iron in the armature, unless to enable the brushes to be rocked, an advantage which would be dearly bought by the low efficiency.

Several attempts have been made to produce a constant current by compound winding, but they do not appear to have met with success. In such a machine the characteristic should be a vertical straight line, but practically it is merely the usual rounded extremity of a shunt characteristic, and the current is therefore only approximately constant. The winding is nearly all shunt, with a few turns of series coils, which are of little use, since it is never necessary to short-circuit the machine, the minimum work being one arc lamp or nothing. The difficulties of insulating, and the expense of winding the fine wire required for high volts would be serious obstacles to compound winding for constant current, even if a fairly constant current could be produced. The method may be worth using for three or four arcs.

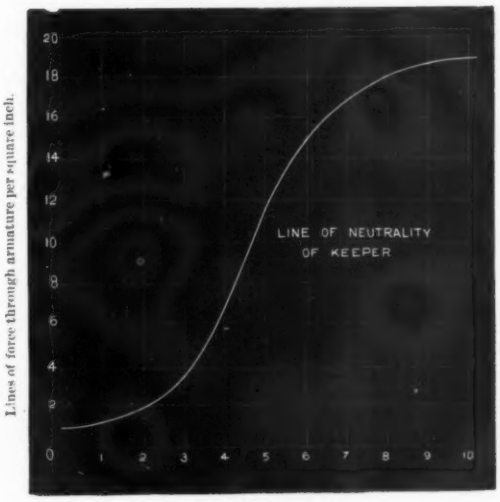
Another method has been employed in the Brush system, viz., shunting a very small portion of the exciting current of the magnets, and thus weakening the strength of the field. It appears that this can be carried farther with a Brush dynamo than with more modern machines. The difficulty is, that if the excitation of the field be reduced to such an extent that its magnetic resistance approaches its initial value, or, considering the saturation curve—when the working point approaches the nearly straight part of the commencement of the curve—the volts become unstable, and the current is liable to drop. If the reduction were very gradual, and the speed perfectly uniform, it might be possible to reduce the volts to a low point if the machine were working on a dead resistance; but with arc lamps it would be impossible, and even with a resistance it is found that from small fluctuations of speed, or some other cause, the instability is always present.

With an automatic regulator to control the resistances used as a shunt to the field the difficulty increases, for it would attempt to correct a small accidental drop of volts by increasing the strength of the field, and serious shunting would ensue. Arc light dynamos of modern design, by several of the leading dynamo builders, have been successfully controlled by the automatic regulator, to cut down to half the full load with a simple shunt. Instability sometimes is present in shunt wound dynamos used at one time for charging cells, and at another at lower volts, for running glow lamps direct, the reduction being effected by adding a resistance to the shunt. If such a machine be compound wound, the instability would only be noticed on a small load.



C Constantly magnetised limb.
K Keeper.
R Regulator and resistances.

FIG. 1.



Ampères round "keeper."

FIG. 2.

In discussing means for remedying this difficulty, Mr. H. W. Ravenshaw, senior electrician to the firm of Goolden and Trotter, suggested that the reduction might be effected *while the field-magnets were saturated* to the usual point, by diverting the lines of force from their usual path from pole-piece to pole-piece through the armature, by offering a path of lower magnetic resistance. It was proposed to do this by employing a movable mass of iron, which had better be termed a "keeper" (in order to avoid the word armature). The mass of such a keeper would be considerable, and in the course of discussing the mechanical problem of moving it by means of an automatic regulator, the writer proposed, instead of moving it, to neutralise its effect by passing a current round it, thus obstructing the passage of the lines of force through it, and rendering it practically inert, non-magnetic, or altogether abolished.

The first practical experiment was carried out a few minutes after the invention of the method, with an ordinary series wound

arc lighter of the Gramme type with Goolden-Trotter modifications, and the results were very satisfactory. The double magnet type of dynamo is very suitable for this purpose, for one half of the machine may be constantly-magnetised to the desired point of saturation, while the other half acts as a keeper. The former may be called the constantly magnetised limb, and the latter the keeper. They are similarly wound with exciting coils. If when the constantly-magnetised limb is fully excited by the usual current through its coils, and no current is passed through those of the keeper, the keeper will act as a magnetic shunt, and nearly all the lines of force will pass round and round in a closed circuit of iron. Little or no polarity will be found at the pole-pieces, and there will be a minimum effect on the armature. By allowing a weak current to pass round the keeper the diversion of the lines of force through it will be partially obstructed, and the rest will take their usual path through the armature. With a certain strength of current this obstruction will be complete, no lines will pass in either direction, and the magnetic effect is the same as though the keeper had been entirely removed from the dynamo. The strength of the field and its action on the armature is the same as though the dynamo were provided with one magnet only. If now the current through the coils on the keeper be increased beyond this neutral point it will assist the permanent magnet; the lines of force in the former will be reversed, and finally when the whole current passes round it the volts are at the maximum, and the dynamo works as an ordinary series-wound machine.

It was soon found in practice that, owing to the complete magnetic circuit formed by the pair of magnets, the changes in the strength of the field were somewhat sluggish. This was easily remedied by making a gap in the magnetic circuit, by boring out the yoke or side where the magnet bars pass through and bushing them with brass, using brass washers also on the ends of the bars and under the nuts. Experiments have yet to be tried to ascertain the minimum dimensions of this non-magnetic gap. It is important that it should not be too great, not so much on account of the greater expenditure of energy required for the magnet coils, as for the reason that if the magnetic resistance be high it will be impossible to reduce the volts of the machine to a low point. It is evident that the method consists in shunting the useful magnetic field, and the minimum effect can only be obtained by a magnetic short circuit, and the presence of the gap, if of large dimensions, prevents this short-circuiting or diversion from being complete. The difference of magnetic potential at the pole-pieces will be practically as great as that at the gap when the keeper is neutral. In the second experiment, in which the gap was introduced, the volts of the machine could not be reduced, for this reason, to less than about one-half. It is probable that they can be reduced to from 90 to 95 per cent. without causing sluggish changes.

A practical application has been made of this method for the purpose of running Bernstein glow-lamps arranged in series, and a dynamo controlled on this system by an automatic regulator enables the lamps to be extinguished by short-circuiting. For this purpose an armature of high efficiency can be used, and the current of 10 ampères can be maintained constant within 0·2 ampère.

It is probable that with this system, armatures of considerably higher efficiency can be used for arc lights, especially as such a nicety of regulation is not required. Experiments have not been carried out far in this direction yet. The system is applicable to dynamos used at one time for charging and at another for running direct, or for any other purpose in which it is desired to reduce the intensity of the field to or beyond such a point as will endanger the stability of the magnetisation

The practical control of the current in the coils of the keeper has been effected by the mechanical regulator, which may now be said to be a well known appliance. The rheostat is connected to a set of resistances calculated for the particular dynamo.

The calculations have been worked out by Mr. Ll. B. Atkinson, and the following is an outline of the method which has been adopted:—

Take a series of values of μ, the number of lines per square inch of armature iron. From this number and the magnetic curve of the material a series of values of magnetic resistance are found. To these add the polar air space resistance, and hence determine the magnetic potential between the poles by multiplying the number of lines by the resistance. This magnetic potential must be equal to the total magnetising force (ampère turns) on the constantly magnetised limb, less the value of lines of force multiplied by the equivalent magnetic resistance, or in symbols:—

$$T_1 - \mu_1 a_1 r_1 = \text{magnetic potential},$$

where a_1 is the area of the limb. But T is fixed and μ_1 can be found. This gives the total lines coming to the poles, and these are equal to the lines through the armature + the lines of leakage between the poles + or − the lines through keeper. Having thus found the lines through the keeper, we find its magnetic resistance for those lines, and the ampère turns necessary are found by the equation

$$T_2 = \pm \mu_2 a_2 r_2 + \text{magnetic potential}.$$

Where T_1 and T_2 are ampère turns, a_1 and a_2 are areas, r_1 and r_2 magnetic resistances of the constantly magnetised limb and of the keeper respectively.

The curve (fig. 2) shows how the number of (Kapp) lines of force through the armature is varied by altering the current in the coils of the keeper. It would need a keeper of perfect magnetic conductivity to totally short circuit the constantly magnetised limb.

DISCUSSION.

W. B. ESSON: There is one point in Mr. Trotter's interesting paper about which I should like to question him, having reference to the weight of his machine. It appears to me that the weight of a constant current machine designed on Mr. Trotter's lines must be at least double that of an ordinary arc machine designed for the same maximum load. This for two reasons:—First, in order that under such great variations of field strength there may be no sparking we require very few convolutions on the armature, and consequently a heavy core and working field magnets. Secondly, the weight of Mr. Trotter's keeper is comparable with the weight of his working magnets, and these two conditions conspire to make the machine heavy. I don't say that mere weight is an objection in a machine provided the price can be kept down, but, inasmuch as weight is a factor of prime cost, it becomes important to consider it. I am very much interested in this question, and like most electricians have had a try at designing a constant-current machine. Up to the present, however, I have, like most others, failed. At an early date I was forced to the conclusion that the production of a constant current by mere compound winding was a thing not to be thought of, and the folly of an attempt to do this is easily perceived when we realise fully the conditions which would have to be fulfilled. In a machine compounded for constant potential the variation in the field due to the action of the series wire is about 5 per cent., or the strength of field must be increased from 100 to 105, the lines of force added being for that increase proportional to the current flowing. But in a constant-current machine the variation of field strength through which the additional lines must be proportional to the current is not 5 per cent., but it may be 1,000 per cent. In other words, although the field must rise to ten times its original strength the characteristic must still be straight, and I need not tell practical dynamo makers that this condition is simply impossible of attainment. We must therefore abandon the idea of compound winding and adopt some kind of regulator or brush shifting device or keeper or perhaps a combination of all the lot. In connection with the paper I greatly regret that Mr. Trotter's arrangement has not yet been tried on arc lamps. It is very easy to make a thing of this kind work on dead resistance, such as afforded by incandescence lamps, but when it is tried in conjunction with arc lamps, where the resistance of the circuit is quite unstable, it will be found a much more serious problem, and until it is so tried I am afraid we can judge very little of its working capabilities.

Mr. R. P. SELLON asked Mr. Trotter whether, after the actual trials he had made with a machine in which he had a keeper insulated in the way described, the armature was saturated in that particular machine, or whether he had tried—what he had stated his belief could be done—a dynamo in which the iron in the armature was not saturated. He (Mr. Sellon) found it very difficult to think that stability of current could be obtained even within as wide a range as Mr. Trotter had shown upon the curve. It would be supposed that the effect of the keeper would be to alter; unless the system was saturated to a very great extent the effect of that keeper would be to vary very largely the magnetic capacity of the magnetic system.

Mr. TROTTER, in replying, said with regard to the weight required, it was true that probably if one had to cut down to a very small number of lamps the machine would have to be larger; he should say, roughly, 15 per cent. larger would do for the keeper. There were other ways of doing it. As far as sparking was concerned, in the experiments he had made it was true that the machine did spark slightly: but it was only intended for ordinary purposes, as an arc light dynamo, and therefore was not intended to be put to so strong a test as that which he had described. A sparkless dynamo must be larger than a sparking one, and he did not think the machine with which he made the experiments was a perfect one in this respect. He should think 15 or 20 per cent. extra in weight would be quite sufficient to prevent sparking. The difficulties of compounding were very great. He hoped Prof. Silvanus Thompson would shortly show them how to surmount them. The machine was only made for six lamps, and he had only tried it with that number; they were working perfectly, but that said nothing, because they were fairly good arc lamps, and the carbons were also good. It would be necessary to move the brushes rather more with a compound machine, to prevent sparking. When cut down to one lamp, and from one to nothing, and practically short-circuited, the machine still gave 10 ampères. Mr. Sellon asked if the armature was saturated. It was saturated at the beginning only to the usual point at which the machine was designed to work, and that was somewhat the same as the magnets; that was to say, the magnetic resistance of the armature was somewhere about the same point as that of the magnets, when the machine was working at full load. Of course, it came down under the light load to nothing at all. They had never worked at such a large range as that.

Practical Electrical Measurement. — The articles upon this subject will perforce be suspended for a week or two, as Mr. Swinburne is on a temporary visit to the States.

OBITUARY.

OTWAY EDWARD WOODHOUSE.

MR. OTWAY EDWARD WOODHOUSE, whose death we announced last week, was born in London on October 21st, 1855, was educated at Marlborough College from 1867 to 1872, and was afterwards at King's College, London. He then passed three years as a pupil with Messrs. Hunter and English, engineers, of Bow, during which time he chiefly applied himself to the practical part of the engineering in the fitting shop of that firm.

In August, 1877, he entered the service of the Great Eastern Railway Company (engineers' department), and on Mr. W. Adams, the locomotive superintendent of that railway, changing to the London and South Western Railway Company, Mr. Woodhouse changed with him and continued in the service of that company until the beginning of 1881. In July of 1880 Mr, Woodhouse, in the company of Mr. J. C. Peache, assistant to the London and North-Western Railway Company's locomotive department at Crewe, went to America and spent six months in making a tour of inspection of the engineering and general scientific works both in the United States and in Canada, returning to England at Christmas, 1880.

In 1881 Mr. Woodhouse went into partnership with Mr. F. L. Rawson, under the title of Woodhouse and Rawson. This firm is now well known all over the world, a result largely due to the extremely energetic and able manner in which the business was pushed at its commencement.

The decease of Mr. Woodhouse is primarily due to overwork, for there is little doubt that the extremely long hours he devoted to the development of the business of his firm had a serious effect upon his health.

At the end of 1885, just before the well known action of the Edison-Swan Company against Woodhouse and Rawson, Mr. Woodhouse left London for Cannes, whence he returned to England rather worse, owing to his having caught a fever whilst there. Although he gradually regained strength he never returned to business, and his sudden death on the 21st inst., at Brighton, was not quite unexpected. Before he died Mr. Woodhouse had the satisfaction of seeing his business successfully transferred to a limited company. His funeral, on the 26th inst., at Kensal Green Cemetery, was largely attended by personal friends and employees of the firm, showing the high esteem in which he was held by all who came in contact with him.

Mr. Woodhouse, besides being an able engineer, was well known in athletic circles. Until his work took up too much of his time he played regularly in the lawn tennis championship matches at Wimbledon, being second for the "all comers," and winning the silver prize in 1880. In this year, also, he won the lawn tennis championship cup of America. In addition, he had the distinction of being the only lawn tennis player who has ever beaten W. Renshaw for the championship.

Trunk Line Tolls.—The Western Counties and South Wales Telephone Company has inaugurated a system of tolls for trunk line messages between the principal towns in its district. Subscribers may speak direct from their offices to any subscriber in another town, a monthly account being kept against each. The public has the same facilities extended to it; except that when it wishes to communicate with a subscriber in another town it has to go to the exchange or to a call office. One thing which is unfortunate about the system is, that by its means a man in Bristol cannot accost another man in the streets of Cardiff and hold a telephonic conversation with him. The person spoken *to* in the first instance must be a subscriber; unless, that is, a mutual arrangement is entered into to be at certain offices at certain times. The tolls charged are 6d., 9d., and 1s., apparently arranged according to the distance separating the towns.

NOTES.

The Electric Light in the Royal Navy.—The new armour-plated turret ship *Trafalgar*, which has just been launched at Portsmouth, is to be lighted throughout with over 460 incandescent lamps, besides which four powerful search lights will be fitted in side towers, two on the spar deck and two on the main deck. The turret guns and auxiliary armament of 5 inch B.L. and 36-pounder quick-firing guns will be discharged by means of electricity. Three powerful dynamos of 400 ampères each will be used for these purposes.

The Electric Light in Theatres.—Even so far as Russia has the movement penetrated for reform in theatre lighting, and the new theatre which has just been completed in Odessa, and which will be one of the most sumptuous in the world, is to be lighted by electricity.

Electric Lighting in Spain.—There is at present, according to the correspondent of *Industries* at Madrid, a movement in that city in favour of the adoption of electric lighting, and if important central stations were established, it is probable that they would now be able to do a good business. As it is, the only station at work is on a very small scale, and in consequence theatres, hotels, and clubs are arranging for private installations. The Athenæum Society, of which most Spanish scientists are members, has determined to instal the electric light in its building.

Electric Light on Russian Railways.—The Russian Minister of Ways of Communication has appointed a special commission to select the best system of electric lighting for railway carriages. This is the result of a decision recently arrived at to render the adoption of the electric light compulsory upon the principal railway companies for all passenger trains. The experiments will be conducted on the Nicolaieff Railway, and are not expected to last more than a month. The South Russian Railway Company, it should be noted, has already adopted the electric light for all fast trains running between Odessa and Kieff; while it has been used in the special imperial trains for some time past.

Electric Lighting in Scotland.—Mr. Rankin Kennedy, of Glasgow, has lately fitted out with complete electric lighting plants, the steamships *Wardha* and *Warora*, built by Messrs. Alex. Stephen and Sons, Linthouse, for the British India Steam Navigation Company, the steamship *Elettricco* also built by the same firm, and two oil tank steamers, the *Mococes*, built by Messrs. Russell & Co., Port Glasgow, and *Pollux*, built by Messrs. Pearce Bros., Dundee. These five ships have all been fitted out within the last 10 weeks. The work Mr. Kennedy has now in hand is extensive, comprising the lighting of Portobello Pier, the Scottish Wholesale Co-operative Society's Stores, Leith, and the Flax Mills of Messrs. John Lawson and Sons, Forfar, with 220 lights. He is introducing a new high speed steam engine, specially adapted for ship lighting where space is valuable.

Liberty and the Electric Light.—There is to be a second Liberty, which it is intended shall rival in magnificence and colossal proportions M. Bartholdi's statue at the entrance to New York Harbour. Mr. Adolph Sutro, the millionaire contractor of the celebrated tunnel which bears his name, has announced his intention of erecting a statue of Liberty in the highest part of the twin peaks in San Francisco Bay. The figure and pedestal will be 40 feet high. The electric light will shine from the torch of Liberty. Efforts are being made to secure a light of immense candle-power.

Theatre Lighting.—The electric light has been substituted for gas in the theatre of Jovellanos, at Gijon, in Spain. The installation comprises a Westinghouse motor of 16½ horse-power, two Gramme dynamos of 60

ampères and 70 volts, two arc lights of 300 candle-power, and 120 Swan lamps, 100 of which are of 16 candles, and 20 of 8. All the lamps are arranged in derivation. The working cost per evening of five hours is 6 francs 70 centimes. To this must be added the renewal of lamps, the interest and the redemption of the first outlay of 10,500 francs.

The electric light is being at present installed at the Alexandra Theatre, St. Petersburg.

It appears as if the announcement of the introduction of the electric light in the Lyons theatres is likely to remain a dead letter. The Grand Theatre will open on October 1st with gas lights, as of old. "The authorities have decided in principle," says the *Bulletin International de l'Electricité*, "but it is needful that they carry out their decision, and a certain number of them seem to care little about the matter."

Meantime the exploits of gas continue! The Théatre des Variétés, at Calais, has been entirely destroyed by a fire, which fortunately broke out after the performance was over. There remains merely the walls, and these threaten to collapse.

The apparatus destined for the electric lighting of the Theatre de la Monnaie, at Brussels, has been completed at the works of Leon Gerard in that city, and will be installed, at latest, on October 15th. Electricity will be exclusively employed on the stage, below and above it.

Telephone Wires in Dorchester. — Mr. Henry F. Lewis and the Western Counties Telephone Company are involved in a pretty quarrel with the Dorchester Town Council. This august body claims, by virtue of its ancient charters, exceptional power over the streets and roads of the borough, as well as over the earth beneath and the air above such streets and roads. The Telephone Company, of which Mr. Lewis is general manager and secretary, has run a wire across one of the streets, and the Corporation has requested that this wire shall be removed, upon pain of legal proceedings. Mr. Lewis, relying upon the report of the Parliamentary Committee of 1885 respecting overhead wires (whose recommendations unfortunately were not adopted), asserted his right to erect wires, provided they did not interfere with the "maintenance of the highway free from obstruction and danger," but made what seems a very fair offer, namely, that all wires should be placed, if desired, 35 feet above the roadway, so as to admit of the passage of fire escapes, and to furnish full information of all the wires the company might run in the borough. The Corporation, however, maintained its high ground, prohibited the placing of wires over the public thoroughfares unless its sanction was first obtained, refused to supply any extract from its charters, and threatened that if the offending wire already erected were not removed, "measures will be taken by the Council for its removal." Mr. Lewis, in a spirited reply, pointed out that to apply to the Town Council for permission to erect wires, would be to imply that the company's operations were dependent upon the will of the Corporation, and that any such admission would possibly seriously interfere with its business at Dorchester and elsewhere. Under those circumstances, while desirous of meeting the Council in any way which would not prejudice the position of the Company, he could not comply with the request to remove the wire already erected, and wished it to be understood that stringent proceedings would be taken against any person damaging the Company's property. He gave the Council notice of the intention of the company to erect additional wires, so that if it was desired to contest its right to do so an injunction might be applied for, and the company would cheerfully abide by the decision of a competent court, but did not intend to tolerate any wilful damage to its property. So the matter stands at present, and unless the Corporation of Dorchester waives its "rights as freeholders of the soil of the borough," litigation is likely to ensue.

Telephonic Extension in the West.—The Western Counties and South Wales Telephone Company has now extended its operations to Weymouth and Dorchester, and in the former town a large number of wires has already been erected. The Corporation of Weymouth has called upon the company to enter into an agreement with reference to the erection of wires similar to that now in existence at Bristol.

Tenders for Telegraph Poles.—Tenders are invited for the supply of 7,710 red fir telegraph poles, to be delivered in London, and 16,955 to be delivered at Northumberland Dock (River Tyne) or West Hartlepool. The poles to be felled between 1st November, 1887, and 28th February, 1888, and to be delivered during the following summer. Tenders are also invited for creosoting the above-mentioned poles with either 8 lbs. or 10 lbs. of creosote to the cubic foot, as may be decided. Forms of tender, containing all particulars, may be obtained on application to Mr. W. H. Winter, controller of stores, Telegraph Street, London, E.C. Tenders will be received until noon on Monday, October 24th.

Venezuelan Telegraphs.—The United States Department of State has received copies of a recent contract made between the Venezuelan Government and Cuenca Creus, of Venezuela, for the establishment of telegraphic communication between Venezuela and the United States. The project is expected to result in great benefit to the two countries.

Dissolution of Partnership.—In connection with our note of last week in which we mentioned that the partnership hitherto existing between Messrs. Goolden and Trotter, electrical engineers, had been dissolved, we are further informed that Mr. Goolden will henceforth carry on the business under the style or firm of "W. T. Goolden & Co."

Mr. Trotter will shortly return to London and engage in a branch of engineering, upon which he has not yet decided, but Messrs. Goolden & Co. will still continue to work his patents.

A False Alarm.—A man named William Farmar was summoned before the Arundel County Bench a few days ago for unlawfully making use of the electric communication, while travelling by the London, Brighton, and South Coast Railway, on July 16th. He pleaded guilty and could assign no reason for his foolish act. The bench fined him £2 10s., including costs.

What's in a Name?—We read in the *Referee* that on Saturday next the Gaiety Theatre will once again don its "burlesque" attire, and that a Spanish dancer, Mdlle. Carmen, will pirouette amid the glare of 500 many hued electric lights, all Berry shaped. Mr. Berry possesses a name which, happily or unhappily, lends itself to the perpetration of mild jokes, and in servile imitation of our excellent contemporary we will offer that gentleman a few words of fatherly advice. Don't make a mull-berry, as did your predecessor that goose-Bury, or it may be necessary to call in the assistance of the elder-berry. Send in your bill-berry when it becomes dew-berry, and if Hollingshead should look black-berry, tell him you don't care a straw-berry, which will probably make him look very blue-berry. Above all things avoid the Gaiety bar-berry.

International Hygienic Congress.—The sixth International Congress for Hygiene was opened at Vienna on Monday, and amongst the subjects discussed were "Light and Warmth in Dwellings," and "Progress of Illumination by Gas and Electricity."

Electric Traction in Brussels. — M. E. Julien, the manager of the Société Electrique, has been awarded the Cross of the Order of Leopold in recognition of his services in the application of electricity for traction purposes, as employed on the Brussels tramway lines.

Spiel's Patent Petroleum Engine.—The highest prize, namely, a first-class silver medal has been awarded to A. Shirlaw & Co., of Birmingham, by the Royal Cornwall Polytechnic Society, for the Spiel's patent petroleum engine, exhibited at the Society's annual exhibition this year. The engine was shown driving a dynamo in connection with an electrical installation.

A Big Electrical Litigation.—A suit for the recovery of $1,000,000 has been commenced in the Supreme Court of New York by John B. Powell and others against the Brush Electric Company, of Cleveland, Ohio, and the Brush-Swan Electric Light Company, of New England. The cause of action is alleged non-fulfilment of contract, made in 1883, to furnish Major Powell with certain storage batteries. Attempts to effect a settlement having failed recourse is had to law, and the defendants having possession of immensely valuable property will undoubtedly fight to the bitter end. It will become necessary to call in much expert testimony, and Mr. Edison and other electricians will be called to the witness stand. The interests involved are of enormous value and affect nearly every town and city in the United States and Europe. It is argued among lawyers that the present controversy will have the effect of opening up other litigation as between the various companies. According to the *New York Herald*, probably the most interesting points to be brought out in the testimony will cover the history of the labours undertaken and efforts made by numerous inventors to perfect the system of the storage of electricity.

Electric Traction in Switzerland.—Some trial trips have been made with a new electric tramway from Vevey to Montreuse and Chillon, which have proved very satisfactory. Regular traffic on the line will be commenced on October 1st.

Earth Currents and Terrestrial Heat.—"Wyddfa," writing to *Industries*, says :—"It is a recognised fact that the temperature of the earth increases with depth below surface at the rate of about 1° C. per 60 feet to 90 feet, so that at merely a few miles depth an enormously high temperature probably exists. It is usual to regard this terrestrial heat as the residue of an intense heat which once pervaded the earth's mass, and which has since been and is still being dissipated slowly into space. But since electric currents always produce heat in the conductors they traverse—and the earth is unceasingly traversed by the so-called earth currents—it seems just possible that the internal heat may depend on this cause alone. I would like to ask whether any of your scientific readers consider that the earth currents sufficiently account for the temperature gradient within the earth's crust ?"

The Shoreham Electric Car Trials.—Probably as a result of last Saturday's trials, we read that the North Metropolitan Tramway Company's line between Barking and Canning Town is to be equipped with the cars of the Electric Car Company. Lord Bury, the chairman of the latter company, states that at Shoreham the cost of locomotion does not exceed 4d. per car-mile. Lord Bury, if we are not mistaken, once wrote a paper on primary batteries, and singled out a type of cell which is now no longer heard of, but which, at the time he penned that wonderful article, was to solve the question of domestic electric lighting. Still we hope that in the present case he has formed a correct estimate, and that the company he leads will offer to work the whole of the N. M. T. Company's system at 1d. per car-mile cheaper than it now costs. This would make a difference of over £20,000 per annum in the profits, and would gladden the hearts of the shareholders. At the same time we confess that if Mr. Elieson cannot yet arrive at the working cost of his own system, which has now been in daily operation for nearly three months, it is difficult to see how Lord Bury has made his calculations so exact on an experiment.

Electric Bell Indicators.—The Electric Apparatus Company informs us that it has now nearly completed special arrangements and facilities for an increased output of bell indicators, enabling it to put them before its clients at nearly a third reduction in price, at the same time maintaining its standard of quality.

Telegraphic and Telephonic Reforms.—At a meeting of the Associated Chambers of Commerce at Exeter on Wednesday, resolutions were passed in favour of the appointment of a Minister of Commerce, lower telephonic charges, greater facilities for a cheaper telegraphic night service, &c.

Mr. Harris and Fire Precautions in Theatres.—Mr. Augustus Harris, of the Drury Lane Theatre, applied at the Glasgow Justice of the Peace Court on Monday for a licence for the Glasgow Grand Theatre, which he was opening under the old licence with the play of "Youth ;" but the magistrates, taking into consideration the Exeter disaster, adjourned the application until to-day, as they wished to inspect the theatre. They also resolved that all the Glasgow theatres should have hydrants on every floor, and four on the stage stairs from the flies, and that firemen should be present during the performances. They recommended that the Grand should have a fireproof curtain, and an iron door separating the dressing rooms from the theatre, specially for the protection of pantomime children and ballet dancers, also bills in the auditorium indicating the way out. Mr. Harris said he had patented a curtain with water at the top, and the curtain thus saturated was fireproof. It was, he added, the interest of all theatrical managers to make theatres safe, as the Exeter fire had much injured them. Augustus Druriolanus has very funny notions. The use of the electric light in theatres he deprecates, because, with a wisdom only second to that of the mighty Solomon, he points out that if the conductors are not big enough they will get heated and cause a conflagration. Reasoning in a similar manner, we arrive at the sage conclusion that if his curtain has its supply cut off, a contingency which might of course happen in the ordinary course of events, his device would not, to use a technical and forcible phrase, "hold water." "Youth," we know, will be served, but what a chance for a veteran like F. C. Burnand to make a stage success of "The Hydrant, the Hose, and the Water Curtain ; or, the Absent-minded Turncock."

Underwriters' Wire.—At its recent meeting the Association of Edison Illuminating Companies unanimously adopted the following resolution :—"That in consequence of the fact that 'Under-writers'' wire, so-called, has been shown by experience to be unreliable and treacherous in its action, and we regard it as introducing injurious possibilities in all interior wiring, we discountenance its use and urge upon the attention of the companies composing this association the desirability of abolishing it entirely in the work of wiring buildings over which they severally exercise a control."

Electric Railways in Canada.—Mr. J. H. Killey, of Hamilton, Ont., writes to the Ottawa *Evening Journal*, advocating the use of the great water-power of the Ottawa to generate current for electric lights and the street railways. Steps have, in fact, been taken in this direction. He adds : "An electric railway is now being equipped between St. Catharines, Ont., and Thorold. It is six miles in length. The dynamo will be run by water-power from the Welland Canal. An electric railway is also under construction at Niagara Falls, Ont. It will be near the water level in the gorge from the Suspension Bridge to the Falls. There will also be two electric double elevators and electric lights in cars and along the line of the railway, the writer having to superintend its construction, &c. The motive power to run the generators will be steam."

Electric Locomotion in England and America.—After preaching a crusade in favour of the adoption of electric modes of traction on tram lines, and pointing to America and what has been accomplished there in the way of electric locomotion, as an example of what might be done in England, it is not a little startling to be suddenly confronted with an item of news like the following in an American paper:—"The directors of the North Metropolitan Tramways Company, of London, England, have decided to substitute electricity for horses as a motive power for street cars, and have ordered 300 cars on the new system. A prominent English railway official predicts that within two years not a single horse will be used on the London tramways. We commend this important item for the consideration of all American street railway managers." This will be news to the Elieson Locomotive Company, and we doubt if even the directors of the North Metropolitan Company were before aware that they had formed so heroic a resolution. *Practical Electricity* is a new periodical, and doubtless wishes to make its mark and attract attention; we cannot commend or thank it, however, for in the first place publishing a statement which we are sorry to say is not one of fact, and then holding up England as an example in the same way and for the same purpose that we have been directing attention to America.

Safety of Alternating Currents.—At the meeting of the Chicago Electric Club on September 5th, Mr. C. C. Haskins read an able and interesting paper on the "Peculiarities of Electric Currents," in the course of which he expressed some doubts as to the greater safety now claimed for alternating currents in cases of shock. He illustrated his remarks and views by experiments.

Submarine Boats.—The Paris *Figaro* describes a new submarine torpedo boat, impelled by electricity. The boat measures 8½ metres from stem to stern. Its prow is rather rounded, which renders it better able to bear the shock of the waves, but reduces its speed. The motor is a dynamo machine devised by Captain Krebs, which drives a screw of 0·55 metre in diameter. The electric power is obtained from a novel accumulator which is kept a secret, but which contains neither lead nor acid. Twenty kilos of this secondary battery yield 1 horse-power. It is said to furnish on discharging all the charge which it has received. The total weight of the battery is 2 tons. The 132 accumulators, connected in series and distributed in three chests, are placed at the bottom of the hold. The boat attained a constant speed of 6½ knots for 5 hours, with the expenditure of 12 horse-power. The instruments of measurement showed during the discharge 87—89 ampères with a potential of 100—104 volts, or say 9,000 watts, or a development of 12·22 horse-power. The boat is absolutely silent; there is no smoke, no light, no elevated masts. Reservoirs of compressed air serve to maintain the respiration of the crew. There are two helms, the one vertical and the other horizontal. The *Figaro* expects that this invention will give France the uncontested sovereignty of the seas.

The Cable Rate War.—The *New York Herald* says it "has undoubted information that Gould's cable pool have decided to make war to the knife on the Mackay-Bennett cable by reducing the rate to 6 cents a word, so as to force them to sell out or join the pool, and advance the rate to 60 cents. This Messrs. Mackay and Bennett cannot afford to do. They would rather lose the millions they have put into the enterprise than submit to the dishonour of promising the public one thing at the start and in the end doing another, and they are therefore ready to meet this rate." Manager Ward has been interviewed at his home at Brooklyn. He states that the business has already increased upwards of 130 per cent. in volume. They are now receiving a large patronage from the west, and he is confident that they will have all the business they can handle.

The Light Appreciated.—Electric lighting is no longer an experiment in this city, says the *New York Epoch*. Its advantages over gas are so many and so manifest that even if the electric lights cost a great deal more than they do, it would be economical to use them. They are great crime-restrainers. A dozen electric lights and one policeman will take better care of a given extent of territory than half-a-dozen policemen without the electric lights. A long step has just been taken in providing for an extension of the electric lights to all the avenues, all the streets leading to ferries, and all the principal cross-streets. It is only a matter of time when all parts of the city will be lighted in the new way.

NEW COMPANY REGISTERED.

C. Townsend, Hook & Co., Limited. — Capital, £100,000 in £10 shares. Objects: To acquire the business of C. Townsend, Hook & Co., of the Snodland Paper Works, Snodland, near Rochester, Kent (including the business of manufacturing and supplying gas as well as paper manufacturing). Also to carry on, so far as may be considered convenient, in connection with the business of the gasworks of the company, the business of providing and supplying for public and private purposes in Snodland and neigbourhood, electric light, electricity, and electrical currents or force; and to manufacture, deal in, and let on hire all necessary apparatus, fittings and appliances. Signatories: *Thos. May Dunster, 202, Upper Thames Street, 50 shares; *W. Tennant, 9, Mincing Lane, 50 shares; *Mr. Alderman Tyler, 17, Queenhithe, 50 shares; J. G. Gibson, 25 shares; J. Bates, 20 shares; J. Hyde, 20 shares; and Wm. Dedrick, 25—the addresses of the last four being at Snodland, Kent. The signatories denoted by an asterisk, and Colonel T. J. Holland, are the first directors—qualification: £500 in shares or stock; remuneration, £150 per annum in respect of each director, with an additional £150 per annum for the chairman. Registered 26th inst. by Hunter & Downes, 44, Coleman Street.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

United Telephone Company of Rosario, Limited.—An agreement of the 15th ult. provides for the purchase by this company from the River Plate Trust, Loan, and Agency Company, Limited, of the lines, posts, apparatus, machinery, rights, properties, and privileges of the United Telephone Company of Rosario. The purchase consideration is £39,930, payable as to £19,930 in fully paid shares, and the balance by the issue of 200 debentures of £100 each, bearing 6 per cent. per annum interest.

Leete Edwards and Norman, Limited (engineers, electricians, &c.).—An agreement of 25th ult., filed on the 10th inst., provides for the purchase by the company of the engineering business carried on by Messrs. Leete Edwards and Norman at 368, Euston Road, the consideration being £6,550, payable by the issue of 1,110 fully paid shares, and 10 debenture bonds of £100 each, bearing 6 per cent. per annum interest.

Medical Electric Belt, Truss, and Health Appliance, Limited.—The statutory return of this company, made up to the 26th inst., was filed on the same day. The nominal capital is £20,000 in £5 shares. 200 shares have been taken up, and the full amount has been called and paid thereupon. Registered office, 58, New Bond Street.

United Telephone Company, Limited.—The annual return of this company, made up to July 5th, was filed on the 26th inst. The nominal capital is £500,000, in

£5 shares. 99,022 shares are taken up, 80,000 being fully paid, and 19,022 being paid up to the extent of £2 10s. per share. The paid up capital is £447,555.

Cowles' Syndicate, Limited.—The registered office of this company is at 36, Lombard Street.

Northern Electrical Engineering Company, Limited.—The registered office of this company is situate at 36, Victoria Street, Liverpool.

CITY NOTES.

United River Plate Telephone Company, Limited.—The directors have declared an interim dividend of 2½ per cent. (being 2s. 6d. per share), tax free on the paid up capital, payable on and after the 15th prox.

Eastern Extension, Australasia, and China Telegraph Company, Limited.—This company gives notice that the accounts for the half-year ended June 30th last show, subject to audit, a balance of profit of £66,655 after the payment of the interim dividend for the first quarter. The directors have declared a dividend for the quarter ended June 30th of 2s. 6d. per share, free of income tax, payable on October 15th, and decided to carry the balance of £35,405 forward to the next account.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the three weeks ending September 23rd were £2,406, £1,373, £1,578, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited.

CORRESPONDENCE.

The D'Humy Battery.

In your paper of September 23rd you publish under the heading, "An Explanation Necessary," a letter signed R. E. Crompton, and the editor added to it a note of his own.

Mr. R. E. Crompton is no doubt a great man since he has been at Vienna. The original report signed D. Monnier, and dated July 1st, 1884, is in my hands, and can be seen by every person at my office.

I am not aware that Mr. R. E. Crompton has ever been able to obtain any concessions to light any city in Europe, this is not the case with me, as I have at present the contracts and concessions for more than 200,000 lamps.

Mr. R. E. Crompton and Mr. D. Monnier must have very bad memories, or be animated by very improper motives to make such statements, which are absolutely false, as I will prove by Mr. D. Monnier's own letter to me.

P. D'Humy.

September 28th, 1887.

[This letter is about as much to the point and as intelligible as that published last week by our esteemed contemporary the *Electrician*.—EDS. ELEC. REV.]

The Causes of Unsteadiness in Arc Lamps.

In criticising my original letter on the subject of unsteadiness in arc lamps, the remarks of Mr. Charles Lever indicate rather a feeling of irritation than a sincere desire to correct those mistaken ideas of which he seems to regard me as the victim. A facetious trans-Atlantic critic has, if my memory fails me not, classified my opponent amongst those electricians "afflicted with a 'system.'" Let your readers bear this fact in mind, since some of them might have lost sight of it, and excuse for this reason the frequent incoherence of my estimable adversary.

Mr. Charles Lever has invented a lamp, and a time-dimned image which I evoke from my inner consciousness represents the luminous invention in question, as one of the many, many contrivances comprising one of those wonder-working rings, compared with which that of the Oriental myth is but an ordinary every-day bauble, and, ancient though it be, retaining even a charm of the most inscrutable nature for the would-be inventor, through whose night-time visions dances ever the annular organ of the most "puffed" and most talked about of arc systems; whilst amid the patent office records its ubiquity rivals that of the unctuous and much-adored dash-pot deity!

Moreover, the lamp of Mr. Charles Lever works with a short arc (for reasons no doubt best known to the inventor), and since I have not chosen to express my admiration of the short arc, I am simply told that I do not know what I am writing about. Fortunately, I may console myself by the reflection that this result was absolutely inevitable, for the reason that all inventors are extremely irascible and invariably indulge in an immensity of barking after the luckless critic who does not admire their "notions." Remembering how many a time and oft our esteemed editors' ever carefully weighed strictures have stirred up the ire of the bellicose patentee, the ordinary mortal should feel no surprise if the same treateth him like unto a "hoss thief," as the language of the Western Republic hath it.

Happy, indeed, are we that the use of the "cow-hide" and "six-shooter" entails more serious consequences in civilised Europe than in the remote parts of Columbia's realm, and that the heroism of the average inventor riseth not to those epic proportions which call for the rifled pistol and the triple-edged rapier, otherwise the astonished world might witness most sanguinary work!

As things stand at the present period such doings are scarcely possible, and so Mr. Charles Lever merely sets about demolishing me (in print), with all the energy an inventor defending his offspring generally displays. Nor does he seem to consider that a reasonable clearness or coherence of style is necessary in discussing the views of a personage as heretical and viciously disposed as myself, for, verily, all the diligence of the fabulous cock might vainly be expended in the attempt to disinter the meanings which, pearl-like, may bestrew the dimness of my opponent's diction!

Nevertheless, I will do my best, and to begin at the beginning, I would ask Mr. Charles Lever how his hypothetical man, with his hundred and fifty carbons (why a hundred and fifty?) can have anything to do with the subject under discussion? It would also be satisfactory to know how my critic has managed to construe my letter as an "attack" on Mr. Swinburne. Evidently the gentleman in question must feel himself highly flattered by the reception accorded to his misunderstood axioms by Mr. Charles Lever. Although not an authority on the subject, he has chanced to "hit the right nail on the head" (admire the elegance of the expression), and has thereby merited the approval of so eminent an "expert" as Mr. Charles Lever. This is indeed gratifying! It is to be feared that after such a triumph Mr. Swinburne will rest upon his hard-earned laurels, and that the readers of the ELECTRICAL REVIEW will be deprived, at least for a time, of the pleasure of perusing his interesting contributions.

The right direction to work in is found, cries Mr. Lever, and proceeds forthwith to demonstrate, at least to his own satisfaction, that the desired result may be obtained by means of certain antiquated devices which everyone is free to use. This seems to me contradictory at the least, but, perhaps, I am too obtuse, and seize not the subtleties of Mr. Lever's logic.

Neither do I recollect having stated that the "sole remedy for unsteadiness is the employment of a cored positive carbon." It seems to me that after having discussed the various causes of unsteadiness in arc lamps I might well have been accused of incoherence had I cited the cored or "wick" carbon as the *sole* means of remedying this disagreeable defect; on the contrary, I expressly stated that the core simply prevented the shifting of the arc. Of course this shifting, which takes place invariably when solid carbons are employed, may have a greater or less effect on the light according to the regulator used. The "curious fact" announced by Mr. Charles Lever

presents itself in all lamps which are too sensitive to variations of the arc resistance, such as the Serrin for instance.

Mr. Charles Lever chooses to condemn cored carbons as being "an excuse for bad lamps," a by no means brilliant remark, which, if it means anything, goes to prove that the steadiness of all lamps is augmented by the use of these electrodes. In practice this has long since been proved, while theory indicates the core as the simplest means of doing away with a cause of unsteadiness, which the most perfect construction of the regulator can never eliminate, namely, the shifting movement of the arc. It is evident, moreover, that the core counteracts the effect which the unequal mechanical or electrical resistance of the surrounding carbon mass might have upon the arc.

That solid carbons give a greater photometric effect I am disposed to deny. Mr. Charles Lever seems to refer not to tests but to the apparent brilliancy of the light, and although photometric measurements are unreliable, an opinion based upon the simple effect upon the retina is certainly even less worthy of credence. Probably, in order to make the lamp work passably well, the solid carbons were employed with a short arc, in which case the greater horizontal intensity and the smallness of the luminous point would induce the careless observer to imagine a higher efficiency.

Mr. Lever next treats the question of cost, and seems to fancy that the price of cored rods must necessarily be twice that of solid carbons of the same quality. This I deny, although admitting them to be dearer than the American trash which Mr. Lever admires. The arithmetical exercise of my respected opponent is valueless, since, if unsteadiness is regarded as of no importance, A's tender would be accepted, whereas if fixity of the light is required, B would have the greater chance of success.

The assertion that clutch lamps will give a steady light with cheap carbons whilst the more complicated regulators will not do so, is somewhat nonsensical for the reason that all the "more complicated" systems do not "pump" like the Pilsen.

If Mr. Charles Lever thought fit to justify his assertion that I have advocated certain "complicated, expensive, and utterly useless devices," I should have been highly gratified, otherwise I shall be obliged to persist in the belief that my critic has not troubled himself to comprehend the contents of the communication which he is pleased to criticise.

It appears that I have displayed a complete want of knowledge in condemning the short arc, but we are not enlightened as to the "many advantages" of this system; nevertheless, everyone will be glad to hear that the light emitted by a short arc lamp is "produced partly from the arc and partly from the incandescence of the carbons." Erst have I in my ignorance imagined the same to be true of all arcs, whether short or long or of medium length, but this seemeth to be but a "vulgar error." It is also stated that "this feature" is "particularly valuable." Why, we are not informed, but treated instead to a rather strangely worded passage about men working with their backs to the light, &c. I do not desire to play the hypercritic and therefore let pass this curiosity in style.

Having said approximately the same thing, I could hardly be expected to deny that "it is no difficult matter to make a short arc lamp burn steadily," that is, relatively speaking, since a certain extremely rapid vacillation of the light must always exist. The hissing sound, regarded as unimportant by Mr. Lever, is, moreover, a most serious defect.

For the reason that Mr. Charles Lever mentions long arcs in contradistinction with short ditto, I take the liberty of reminding that gentleman that I have never advocated the use of *long* arcs, but have expressly stated that there is a medium arc length which gives the best results, pointing out at the same time that a regularly working and well adjusted lamp was required to maintain this distance constant, a result absolutely unattainable with the ring clutch system.

Mr. Charles Lever often vaunts the "steady" light obtainable with cheap solid carbons and clutch lamps, but as steadiness can in this case be merely a relative term, and means very little, especially amongst Saxon electricians, I would counsel your readers not to place too much faith in this assertion. I, for my part, do not see why an arc regulator should not give an absolutely steady light, even as unchanging as that of an incandescent lamp. It is, I think, undeniable that the unsteadiness of most of the arc lights in the market has done much towards diminishing the popularity of the system, and has thus allowed such monstrosities as 500 candle-power incandescent lamps to come into being.

Notwithstanding the corrections contained in my last week's letter, the same hath been likewise mutilated by the typographical demon.

Allow me to enumerate the errata:—

Firstly, I would point out that I qualified the "dash-pot" as a "*viscous* make-shift." Secondly, that I never heard of the lamp of "Grovin;" let the puzzled reader replace this unheard-of name by that of *Gravier*. Moreover, that I wrote of the solenoid as being *superior* to a magnet for the regulation. I ought also to remind the "typo" that the word signifying in the Gallic tongue the solar orb is spelt *soleil*. Finally, for "*best* known," read "*least* known" in the passage on the arc-striking magnet of Abdank.

Although correcting the errors of your "typo," I would in no way desire to exaggerate his responsibility. Well do I know that the printer, endowed with fiendish attributes by tradition, is generally a hard-working and long-suffering victim of the innumerable authors who seem to—

. . . . "hold it as our statists do,
"A baseness to write fair."

F. de Wolffers.

Paris.

[We can endorse most unhesitatingly the concluding remarks of M. de Wolffers; his own caligraphy furnishes an excellent illustration, or perhaps it would be more correct to say an awful example, of the difficulties with which the poor, wrongly-abused compositor has to contend. If M. de Wolffers will, in any future communications with which he may honour us, write with *black* ink and on *one* side of the paper only, he will earn the gratitude of a long-suffering body of men.—EDS. ELEC. REV.]

Insulation of Underground Wires.

My notice has just been directed to the letter published by you on 9th inst. on the "Insulation of Underground Wires," signed "W."

I would like to know in what city your correspondent had the experience of our system which does not lead him to place much faith in this method of insulating and protecting underground wires.

I know of none where such an opinion could fairly be formed, for wherever our cables have been properly laid they have neither given trouble to us nor to those running the installation.

Your correspondent gives us but scant justice when he admits (rather reluctantly it seems to me) that there are many instances where it has been "fairly successful." As a matter of fact, nearly all the underground mains in use up to the present time for public or private lighting are of our make, and I can give some hundreds of instances where our cables have been so employed with perfect success.

His remarks as to the use of bitumen in America are somewhat wide of the mark. We are kept well posted as to all that is doing in the States from our factory at Newark, and I have just returned from New York, but I have failed to hear of those daily trials of bitumen combinations which, he says, are being made there, only to be daily abandoned. The working systems in America are essentially "bituminous." The whole of the incandescent feeders laid underground are either of

our cables or of Edison tubes, and these latter depend on plain bitumen simply for their insulation. No small part of the little underground work there is, on arc circuits, has been done by us, and as we have laid the feeders for 10 large central stations in various parts of America we claim to know something of underground work, and of the success which our system has had.

I fear "W." has given too much attention to theoretical perfection. Whilst others have been discussing possible and impossible systems we have been doing steady, practical work with our own, and know that it will answer now and in the future the requirements of the men who do the work.

T. O. Callender, *Manager,*
FOR CALLENDER'S BITUMEN TELEGRAPH AND WATERPROOF COMPANY, LIMITED.

September 21st, 1887.

Under the above title a letter appears in your issue of September 9th, signed "W.," in which the writer, on the plea of "the general interest of the subject," takes pains and exercises his ingenuity in an attempt to injure the reputation of the Berthoud-Borel cables.

Without following "W." in decrying everything, it may be remarked that however "good" the quality of India-rubber may be, it will never withstand melting on the temperature rising to its melting point, and seeing that the more rubber there is in a composition and the lower will be its melting point, it is very doubtful as to whether any "good admixtures of this material" can be made.

No proof is given by "W." that cotton thoroughly coated with a composition of linseed oil and resin absorbs moisture; nor that the two layers of lead, with intervening layer of pitch (not tar), do not form an "efficient outer insulating covering." That the cotton so coated and covered does *not* absorb moisture, and that the layers of lead and pitch *do* form an "efficient outer insulating covering" is shown by what follows.

"W." does not describe the process of coating the cotton-covered conductor with the composition correctly. The linseed oil is not "oxidised in a special manner with resin;" the resin is used to *thicken* the linseed oil, but does not "oxidise" it, and the linseed oil and resin composition *alone* are not boiled for two or three days to get rid of moisture; but, after immersing the drum on which the cotton-covered conductor has been wound, in the hot composition, the temperature of the latter is maintained at its boiling point for two or three days *to get rid of all moisture from the cotton*. Of course the composition loses its moisture at the same time. No doubt oxidation of the linseed oil does occur, but that is not the primary object of the continued heating, nor is it essential. "W.'s" remarks, therefore, on this point, are directed against *his own description of the process*, and do not apply to the correct account.

That the cotton after coating does not absorb moisture is shown by the fact that cables which have been laid for three years in trenches saturated with water—in the town of Greenock for example—have maintained their original high degree of insulation, so that the layers of lead, pitch, composition, and cotton, do form an "efficient outer insulating covering," and the "use of cotton" is shown not to be "an undeniable source of weakness." The only points at which moisture can possibly be absorbed are the ends of the cable, and these are directed to be cut off when the cable is laid and connected.

In reply to what "W." advances as to the composition becoming hard and brittle, it may be well to remind him that very much depends upon conditions. Linseed oil containing resin in solution becomes hard and brittle *on exposure to the air*, but the composition in the cable is enclosed in a leaden tube, and is practically *sealed up hermetically out of contact with air* (except at the ends, as above mentioned), so that *no hardening occurs and no brittleness is developed*. This is no merely theoretical explanation, but the result of the examination of samples of cable. Surely it is a matter of common experience that varnish laid on an exposed surface hardens, but that it does not harden if kept closed up from contact with air, in a bottle. The composition in the cable is in an exactly similar position to the varnish in the bottle.

"W.'s" notions as to the separation of the resin while the composition is kept hot, owing to its "specific gravity" being greater than that of linseed oil, are altogether wrong. *The resin is dissolved in the linseed oil*, and *not simply mixed with it* ("W." admits the "solvent action" in his next paragraph). That a liquid, containing a solid dissolved in it of different specific gravity, will, while kept at a high temperature, and with the concurrent motion necessarily produced by the flow of heat into it, allow of the separation of that solid, according to its specific gravity, is scientifically incorrect. "W." evidently has that little scientific "knowledge" which is "a dangerous thing."

The heat-resisting quality of the composition is necessarily dependent upon its melting point, and since it is the fact that in covering the coated conductor with lead, the composition is, at most, only softened on the surface in immediate contact with the molten lead, it will be seen that, as the melting point of lead is 315° C., the composition has in this respect a great advantage over both India-rubber and gutta-percha, which melt at 105° C. and 120° C. respectively.

"W." should supply proof of his statements that the high temperature and the fatty acids of the linseed oil act injuriously upon the cotton covering of the conductor as regards its "mechanical attributes." The cotton being heated *in the composition without access of air*, is capable of standing a high temperature without injury better than it would if air were present. I am unable to find any experiments in support of "W.'s" contentions on these points; and in view of the facts that there is no air present, and that an abundant supply of the composition surrounds the cotton, protecting it from any undue action of the heat at any part, any injury from that cause is, to put it mildly, highly improbable. Admitting for a moment that the fatty acids act injuriously (which I do not admit, but call upon "W." to give his authority for), the presence of the resin would be quite sufficient to prevent it. Here, again, "W." forgets, or ignores the conditions.

Fatty acids certainly act on many metals *in contact with air*, but here *air is excluded* (and moisture too); even acetic acid, a much stronger acid than any fatty acid in linseed oil, is without action on lead in absence of air. So much on the score of probability *a priori*. As to actual fact, it is found that the surfaces of the metals of the cable are quite clean and bright on removal of the composition, entirely negativing the idea of the slightest corrosive action. These remarks apply equally to the layer of pitch (tar is not used) which separates the two lead coverings.

Lead will last underground without change for an enormous length of time. For example, water pipes of lead have been found at Pompeii and in many old Roman remains on the Continent, in which the lead was preserved intact. Such being the fact, will "W." uphold the opinion that lead pipes made in modern times, with all the advantages of greater scientific knowledge brought to bear upon their manufacture, will not last as long? The remarks already made as to the preservation of insulation also bear on this point, and show "W.'s" argument to have no foundation to rest upon.

A few points remain to be noticed. No paraffin has been used in the composition for coating the conductors for the last nine years, so that all "W.'s" remarks on that head are beside the question, and are erroneous to boot. No hemp is used for the fibrous covering, only cotton; cotton only is spoken of above. No tar is used, only the pitch left after distilling off the volatile hydro-carbons and acid bodies from coal tar. It can be shown that the lead covered cables are less clumsy to handle than others.

That the defects "W." has attempted to show exist in the Berthoud-Borel cables are altogether imaginary is pretty conclusively proved by the above facts, which, without further comment, I leave to the consideration of your readers, merely remarking that it is to be regretted that "W." did not obtain more authentic information before writing.

F. I. C., F. C. S.

The Bonta Telephone Patents Analyzed.

Having read with very great interest the article headed "The Bonta Telephone," in the ELECTRICAL REVIEW of September 2nd, I made inquiry as to where the Bonta telephone could be seen, and having learned that the office of the American National Telephone Company was at 26, Broadway, I went thither in company with a friend of great scientific attainments, especially in electrical and telephonic matters.

The person in charge showed us the instruments, and allowed us to converse by means of them from one room to another room. The articulation was very distinct (the receiver, however, was an ordinary Bell receiver), when our conversation was carried on in ordinary tones—but when the tones were raised—and we spoke in a loud tone, but not very loud, there was no articulation perceptible, and we could not understand what was said into the transmitter. All we heard was a continual rattling and snapping, indicating that the electrodes were continually being separated.

We then examined the construction of the transmitter, and we both were satisfied, first, that the instrument was simply a carbon microphone; second, that when the articulation was good, it acted as a microphone by variation of pressure of one electrode against the other; third, that when the electrodes were separated by the vibrations of the diaphragm there was no articulation, and not a word could be understood; fourth, from these trials we were convinced that the instrument worked as a closed circuit when speech was successfully transmitted, and that when breaks and makes were made, it did not work successfully. In fact, it operates in exactly the same manner as the Blake transmitter. The experiments described in your article, "with the magic lantern with microscopic attachment," were made in a dark room, and the sensitized paper upon which the image of the carbon electrodes are projected represented them "in every condition of separation or contact" as described and exhibited by the photographs in the *Scientific American* of August 13th.

In the description of the Bonta telephone are the following lines: "It is exceedingly sensitive. The speaker may stand off several feet with his back turned to it, and it will transmit all his words."

This very *sensitiveness* seems to me to furnish conclusive proof that the instrument is simply a carbon microphone, and acts without breaking the circuit and necessarily produces what is termed an undulatory current.

Before leaving we were each presented with the prospectus of the American National Telephone Company. On my return to Washington, I went to the Patent Office, and procured copies of patents issued to James W. Bonta, No. 333,816, January 5th, 1886, and No. 361,124, April 12th, 1887. I also examined the complete file of all the papers in the case of patent No. 333,816, of January 5th, 1886. I now present an analysis.

First.—Of the experiment with the magic lantern. When that experiment was made, the instrument was not connected to a line with a telephone receiver in the circuit, so that there was no evidence that articulate speech was transmitted at the time the photographs were taken—also the speaker fairly *shouted* into the transmitter, and breaks and makes were necessarily made—just as they were when my friend and myself spoke loudly and got no speech—and again the force of the air waves necessary to cause breaks and makes depends on the inclination of the plane in which the carbon ball is placed. This experiment seems to me to be simply "a snare and a delusion." I may be mistaken, for we all are liable to err. So much for the experiment with the magic lantern.

Second.—An analysis of the patents above referred to shows that the instruments described and the drawing of them exhibited are identical in construction and in operation. I send to you these two patents, wherein you will see that the figs. 1 and 3 in the patent of January 5th, 1886, are identical in construction with fig. 9, in the patent of April 12th, 1887, and these are the only figures shown in those patents.

The claim in the patent of January 5th, 1886, is in the following words:—

"What I claim is: The art or method of transmitting articulate speech or other sounds telephonically by induced currents over a secondary circuit, which consists in causing speech or sounds to vary the resistance as well as to open and close the primary circuit operated with such secondary circuit, substantially as before set forth."

The following sentence occurs in lines 49 to 53, on p. 2 of the specification.

"Consequently, when the diaphragm is vibrated by sounds spoken or impinging against it the initial contact pressures of the ball are varied, resulting in changes of resistance of the primary circuit."

In the patent of April 12th, 1887, the first and principal claim is:—

"The art or method of transmitting vocal or other sounds telephonically by causing intermittent or pulsatory currents of a uniform volume or intensity, and of durations corresponding to the phases of the oscillations of the diaphragm."

It will be seen that in the patent of January, 1886, the claim is for the transmission of *articulate* speech by *varying the resistances*, as well as by opening and closing the circuit, whereas, in the patent of April 12th, 1887, there is no mention of *articulate speech*, and the three claims of this patent are for the art or method of transmitting *vocal* or *other sounds* telephonically.

The words *vocal or other sound* of course include articulate speech.

The question here arises, why is it that the claim in the patent of January 5th, 1886, is made for *the art or method* of transmitting *articulate speech*, and that in the patent of April 12th, 1887, the claim is for the "art or method of transmitting *vocal or other sounds?* My mind suggests to me that the reason for the claim of the patent of January 5th, 1886, is that the resistance of the circuit is *varied* as well as opened and closed, and that in the patent of April 12th, 1887, electrical impulses are caused, and the transmission of *vocal* or other sounds is claimed, but *articulate speech* is not claimed, as it is well known that the "Patent Office holds that 'articulate speech' cannot be transmitted by the make and break theory," and the examiner who allowed these claims refused to allow any mention of *articulate speech* in any specifications where the *make and break* system is used.

Third.—A brief analysis of the "Prospectus of the American National Telephone Company."

On page 4 of the printed prospectus the following sentences are to be read:

"This method is as new and original as the Bell, and is based upon well known scientific principles, embodying the *intermittent, pulsatory, or make and break electrical circuit.* It is secured by numerous patents to James W. Bonta, of Philadelphia, the principal one having been granted April 12th, 1887, *for the method of transmitting articulate speech* by INTERMITTENT or PULSATORY CURRENT IMPULSES of constant volume caused by OPENING and CLOSING the battery circuit."

On referring to the patent of April 12th, 1887, it will be seen that the claim is *not* for the transmission of *articulate speech*, but for the transmission of *vocal* or *other sounds.*

The prospectus proceeds to say, that "before acting decisively upon the merit of Mr. Bonta's claim, the Patent Office required the inventor to fully demonstrate that the method claimed by him as new, *did not*

employ an undulatory or variable current to transmit speech, and suggested a crucial test which would prove conclusive. Means for making such a test were placed at the disposal of the Patent Office Examiner, who made a careful, protracted, thorough, and exhaustive examination of the invention with reference to that claim. The result was decisive in Mr. Bonta's favour, as the report of the examiner and subsequent allowance of the patent attest."

In the first place, there is no claim in either of Bonta's patents for the method of transmitting articulate speech by intermittent or pulsatory current impulses. That statement in the prospectus is proved to be erroneous by reference to the patent.

In the second place, "the careful, protracted, thorough, and exhaustive examination of the invention by the Patent Office Examiner" was with reference to the action and claim in the patent of January 5th, 1886, wherein the claim is for transmitting articulate speech by *varying* the *resistance of, as well as* by opening and closing the circuit, and not by *intermittent* or *pulsatory* current impulses.

In the third place, on the same page of the prospectus, is the following statement: "It is apparent that the principal or controlling element is the spherical or ball electrode, so arranged in connection with the diaphragm electrode that there is no variation of contact pressure between the electrodes."

Inasmuch as the above statement applies to an instrument identical in construction and operation with the instrument described in Bonta's patent of January 6th, 1886, where the claim is "For transmitting articulate speech by varying the resistance of as well as by opening and closing the circuit," it is evident that that statement in the prospectus is not correct.

That examination by the Patent Office examiner was made about the patent of January, 1886, about eight months before the application on the patent of April 12th, 1887, was filed. It is then evident that the statements in the prospectus above referred are proved by the patents themselves not to be sustained as *facts*.

Fourth.—On page 5 of the prospectus under the head, *Recapitulations*, the third paragraph reads: "Now, therefore, the American National Telephone Company divides the field with the Bell Company, having a new *method*, the 'make and break' circuit patented by J. W. Bonta, April 12th, 1887." To this modest, but broad claim, the patents themselves and the patentee, by the terms, language, and words of his several patents, say, in clear and undefiled English, that nowhere is there any claim for the transmission of articulate speech by means of *a new method, the make and break circuit.*

Even if there were a claim in the Bonta patents for a "make and break" method, such a claim would not be *new*, for the simple reason that Patent No. 318,423, May 19th, 1885, has a claim which reads:

"The method of transmitting articulate speech telephonically, which consists first in causing primary intermittent electrical impulses in the transmitting circuits through the agency of sound waves, due to articulate speech."

I have confined my remarks to statements of indisputable facts, and leave your readers to judge of the merits of the Bonta telephone, without the expression of any opinion thereon by your correspondent.

W. C. Barney.

Washington, *September 12th*, 1887.

Incandescent Lamp Patents.

The letter of Mr. Hamilton, dated 3rd inst., is certainly guarded. He refrains from the expression of his opinions, and contents himself with unsupported denials and a few invitations to me to "come and be killed." With my eyes fully open to the fact that he is thus lying in wait for me, I shall give some information of which he pretends ignorance, though where he fails to respect the amenities of discussion he shall be unanswered.

I did not say that carbons on the lines of 4,576 of 1879 contained anything other than carbon, but that Edison specifies such. One instance of this is in 1,918 of 1881, where boron, silicon, and zirconium are mentioned. Then Mr. Hamilton cannot be unaware that in the patent of 1878 the incandescent material is in manufacture saturated with salts of metals difficult of fusion, which metals are reduced on heating. This patent applies also to incandescent bodies formed of metallic oxides.

The presence of condensed gas in a lamp or elsewhere has no more to do with the pressure than latent heat has with temperature, and, except that a strengthening of his argument accrues, I can see no reason, and none is given, for contending that pressure cannot be measured without heating the globe.

Mr. Hamilton has several times woefully missed the point in my letter. If I thought that the fault lay with me I should put him right, but as there is nothing above the grasp of an ordinary intelligence I do not feel justified in further occupying your space.

D. S. Sinclair.

P.S.—Your compositor, last week, favoured me with several misprints, one of which ruined a quotation, that beginning "I know him not," should read "To know him not."

D. S. S.

September 21st, 1887.

Flickering in Arc Lamps.

In the ELECTRICAL REVIEW of September 16th certain correspondence appears about arc lamp carbons. Mr. de Wolffers considers that the flickering of an arc lamp is caused by the bad carbons used. If Mr. de Wolffers would go to the Great Eastern Railway Station, Bishopsgate Street, he would there see six simplex arc lamps (parallel) burning the cheap form of Brush carbons.

I think I can safely say that he would have to stop a very long time there if he waited until he saw one of these six lamps flicker. When I first used these Brush carbons I was rather doubtful if they would not destroy the steadiness of the simplex arc lamps which I had burning in the Consolidated Telephone Company's factory. It turned out, however, that these lamps burnt the Brush carbons as well as they did the Hardmuth's.

Mr. Lever's remarks about the cost of carbons being taken into consideration in an installation of arc lamps are most pertinent. I fancy he would find in the simplex the lamp that he says will be the lamp of the future, *i.e.*, a simple and inexpensive lamp which will burn cheap carbons without flickering.

C. L. W. FitzGerald.

The Water Primary Battery.

In your issue of the 16th you, as editors, are responsible for a paragraph which in the form of asking questions insinuates unworthy motives to me. The whole aspersion is utterly false and groundless, and as unworthy of your journal as it is untrue.

M. D'Humy does not use my carbon, nor has my judgment been warped by the hope that he would employ it or by other unworthy motive, such as the framing of your questions and comment imply.

I must request you to publish this letter, and call upon you as gentlemen for an ample apology.

Fredk. H. Varley.

September 24th, 1887.

[We have much pleasure in inserting Mr. Varley's letter, but we have yet to learn that any apology is necessary for the paragraph to which he alludes.—EDS. ELEC. REV.]

Decomposition of Alloys.

I have just seen a letter by Mr. Alexander Watt in your issue for September 16th, claiming to have obtained and published some affirmative results respecting the electrolytic decomposition of metallic alloys, and complaining that his work was ignored by the Electrolysis Committee of the British Association in the discussion on Prof. Roberts-Austen's paper on the same subject. On behalf of the committee I am sure I may say that we shall gladly welcome his affirmative results; for hitherto our experiments have led to nothing but negative ones. But when Mr. Watt says he has *published* these experiments surely he makes some mistake. Through his courtesy I have read his three articles referred to (of which, however, only the first had appeared at the time of the meeting), but I can find nothing there said upon the subject, either one way or the other.

Oliver Lodge.

University College, Liverpool.
September 25th, 1887.

Transformers (Continuous Current).

I have observed Messrs. Paris and Scott's letter, but I am not much interested in continuous current transformers. I look upon them simply as dynamos driven by electro-motors, so that the question of their utility depends, in my opinion, on the merits of the electro-motor compared with any other motor, steam or gas.

Considered as distributors, they have one very awkward objection, and that is that there must be commutators, brushes, bearings, and lubricators to attend to at least daily. The beauty of the alternating system lies in the fact that no attendance is required outside of the central station.

I should be very glad to visit any place where distribution is effected successfully among scattered consumers by Messrs. Paris and Scott's transformers.

I may say that M. Cabanellas, of Paris, Zipernowski and Deri, Edison, and others, have tried and patented such systems, but I have not heard of any of them succeeding in distributing by them.

Rankin Kennedy.

Glasgow, *September 26th*, 1887.

Secondary Batteries as Regulators.

We noticed in your valued paper a criticism on our article in the *Electrical World* of August 13th, on "Secondary Batteries and their Regulating Properties." You state that we appear to be labouring under the delusion that the regulating qualities of accumulators when used in conjunction with a dynamo ensure perfect steadiness in the lamps, no matter what kind of machine is used. If you will read our paper a little more carefully you will see that we state, to quote our own words: "Accumulators *may* be charged with a 'series,' 'shunt,' or compound machine; but for this purpose a shunt machine is greatly superior." And, again: "This shows that the shunt machine is the most advantageous for charging secondary batteries." An ordinary compound machine would, if properly wound so that it developed a constant difference of potential at the terminals when run at its proper and constant speed, hardly be supplied with an accumulator to *steady* the lights, for it would be useless to incur the extra expense of furnishing the machine with series coils, unless it could be run at a practically constant speed, for on this the whole automatic regulation depends. With regard to the "series" machines they are rather "obsolete" for running incandescent lamps. The reason of our explaining how a series machine might be used to charge accumulators was as follows:—In many places where arc lights are used and run only at night, it is sometimes very convenient to have incandescent lamps as well without the expense of a special machine; hence in the day, when the machines are not running the arc lights, they might be employed to charge some secondary batteries, which would then be used to run the incandescent lamps while the machines are running the arc lamps. We also stated that the regulation is only obtained when certain conditions are maintained, namely, that the internal resistance of the cells must be practically negligible, which applies when the machine is supplying current to the cells. Then a shunt machine with a "steep" characteristic will give practically perfect steadiness to the light, even if the engine varies slightly in speed. Again, the charging E.M.F. must be kept higher than the counter E.M.F. of the cells. This being the case when the cells are charged, the machine is supplying the current to the mains and little or none is flowing through the cells, or the cells may be supplying current to the mains as well, then the steadiness will depend on the excitation of the field magnets remaining constant. If we had a perfect engine and a perfect compound machine, accumulators, as regards their steadying properties, might be dispensed with. But without this, they are very useful with respect to the regulation of incandescent lamps.

W. Forneau Collins.
Alfred E. Braddell.

New York, U.S.A.,
September 13th, 1887.

Electric Current Meters.

The action of apparatus necessarily based upon a secondary or induced effect are much unlike a gas or water meter, but the ideal current meter should be like them, inasmuch as it should not consume any or but a very minute portion of the force to be measured. Its delicacy also should not be such as to render it uncertain under all ordinary situations when left unnoticed for months, and its range should be, say, from 1 to 100 ampères at least, measuring the whole and not a part only of the current with equal accuracy of performance, and the velocity of moving parts for all ranges for exactness and durability should be slow, nor should it at any time allow a current to flow unmeasured, as would be likely to occur through a stoppage of the moving parts. It thus makes it necessary to provide adjuncts that shall call attention to any stoppage, and a current interrupter in case of neglect to do so. The meter itself should not offer any appreciable resistance, certainly not so much so as to become heated with a moderate current, and alike suitable for continuous or alternating currents of any degree of E.M.F.; and that such a meter can be produced there is in my mind little doubt. Now how far does the very interesting meter of Prof. Forbes, which is now engaging so much attention, fulfil the required conditions? If it is all that can be desired it would be sheer waste of many persons' time now so engaged to try and produce one for that purpose, as in point of simplicity it could not well be surpassed; but what about its economy? It would be interesting to know how much energy is lost in it itself, say, in foot-pounds per hour, for 1 and 100 ampères, as the idea of converting it into heat appears to be a great waste of energy, and if it is necessary to heat the conductor to measure 1 ampère, then we should expect it to burn itself up to measure 100. Again, will not the necessary velocity of the light mica vanes with a heavy current encounter so much air resistance as to be very inaccurate, even if it could stand it? As yet it seems to have been made to a very limited range of current strength; its delicacy, also, and liability to become clogged, or even to be easily tampered with, when the supply would be kept up without record, will detract much from its value in point of simplicity, and that of economy is no less important. The theory lies in a groove that, I believe, few would have prosecuted far; but the main question is, is it a final solution to the problem, and such as to inspire public confidence; or is there yet an open field to inventors to supply a want which is beginning to make itself felt?

Brum.